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CIVIL ENGINEERING.

Description of Lighthouses lately erected in the Red Sea. By W. PARKES, M. Inst.C.E.

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HAVING been instructed by the Board of Trade to make the necessary preliminary surveys for establishing lights to facilitate the navigation of the northern portion of the Red Sea, the author recommended three sites; 1st. Zafarana Point on the Egyptian shore, 50 miles from Suez; 2d. Ushruffee reef, on the western side of the navigable channel of the Straits of Jubal, 150 miles from Suez; and 3d. the Dædalus reef in the centre of the Red Sea, 350 miles from Suez, and 180 miles from the entrance of the Gulf of Suez. These sites having been approved by the Egyptian government, by the Board of Trade, and by the Directors of the Peninsular and Oriental Steam Packet Company, the immediate execution of the works was authorized, upon designs submitted by the author.

Zafarana Point being on the mainland, it was considered most advantageous to construct a tower and light-keepers' dwellings of rubble stone, and to employ native labor entirely, under the direction of H. E. Linant Bey, the chief engineer of the public works department of the Egyptian government. The design presented no feature calling for special remark, and the works had been carried out in a very satisfactory manner. The light was a fixed dioptric of the first order, visi-

ble, over five-eighths of a circle, at a distance of 14 miles. It was first exhibited on the 1st of January, 1862.

The main features of the other sites were then described. The Ushruffee was a coral reef, of which the sides sloped irregularly from the level of a few inches under low-water to a depth of from 8 to 10 fathoms, no part being above the water, and there being very little sand, even in the cavities of the coral. The Dædalus reef was a submerged island with a flat top of an oval form, 1200 yards in length and 450 yards in breadth, the sides being generally vertical, or in some places even overhanging. The actual surface of the coral was about 6 inches under low-water: but there was a small shifting bank of sand near the south-east end, which was dry at low-water, and sometimes also to a small extent at high-water. The range of tide was about 2 feet at springs.

The peculiar conditions which had to be considered in designing the proposed constructions were—First, the force of the sea would be completely broken at some distance within the edge of the reef. Secondly, the structures would have to be built upon the surface of the reef, and not be sunk into it, as no additional security could be thus obtained, while the advantage of the natural platform would be lost. Thirdly, in the absence of any definite experience as to the actual weight which the reefs would bear without being crushed, it was desirable to keep the weight per superficial foot of foundation as low as possible. Fourthly, the buildings had to be designed so as to mitigate the intense summer heat. And fifthly, in the case of the Dædalus, as the materials would have to be brought from Suez, and as there was no anchorage, it was necessary that a steamer should be employed capable of keeping close to the reef in any wind, and of providing quarters for the workmen and storage room for the materials, until a proper depôt and habitation could be formed on the reef itself. These requirements rendered it essential that the materials should be small in bulk, that the several parts should be light and easily handled, and that the mode of putting them together should be as simple as possible.

It appeared to the author that these conditions would be best attained by adopting a structure of wrought iron supported on teak piles, resting on, and the feet bedded in, a layer of concrete, so as to distribute the weight, the surface of the concrete being a little above the level of high-water; and that, by filling in the wrought iron framework with strong corrugated iron, so as to form a series of rooms one above the other, as a central column, with verandas or galleries around each room, likewise partially enclosed, a portion at least of the sun's rays would be prevented from falling on the walls of the rooms, whilst there would be a free admission of air.

As the Dædalus light had only to guard against the dangers of the reefs on which it was placed, it was not necessary that that structure should exceed the limited height that would allow of four tiers of rooms and of accommodation for the lighting arrangements. These together brought the light to an elevation of 62 feet above the mean level of the sea. As the Ushruffee light had to lead vessels past dangers 12

or 14 miles distant, a more powerful light at a greater elevation was required. The height fixed upon was 125 feet above the mean level of the sea. The frame-work was of the same description in both cases, but in the latter case there were eleven tiers, whereas in the Dædalus there were only four tiers. Details were then given of the Ushruffee structure, as being the larger of the two. It was stated that this structure was supported upon eighteen piles, each 18 feet long and 18 inches diameter, arranged in two concentric circles. The inner circle consisted of six piles and was 15 feet diameter, while the outer circle was formed of six pairs of piles (the piles of each pair being 6 feet apart), 37 feet diameter at the top, and the feet spread outwards at a batter of 1 in 12. The feet of the piles rested upon the natural surface, and there were shoulders on each side of the piles resting on sleepers of teak, bedded on the concrete 2 to 3 feet above the surface of the coral. The heads of the piles passed through circular wrought iron collars, to which they were accurately fitted, and any loosening by the shrinkage of the timber was provided for, by fitting a number of wedges of greenheart timber into corresponding grooves in the pile heads, in which they could be driven down when slack. A direct bearing surface was also given by iron screws 2 inches diameter, which passed through each collar, and entered 2 inches into the wood. The collars had projecting arms to which the bottom framing was riveted. The superstructure consisted of a repetition of three main parts, which might be called respectively standards, cills, and radiators. In each tier there were 24 standards, arranged in two concentric circles, and these were connnected at the top and bottom by cills, thus forming two twelve-sided polygons, the corresponding angles of which were connected by the radiators. With the exception of a few parts near the bottom, no separate piece exceeded 4 cwt. in weight. The floors of the rooms were composed of cast iron plates covered with concrete, and from the lowest floor there was suspended a hemispherical water tank, capable of holding 1500 gallons. The floor of the galleries were formed of open cast iron gratings. The whole of the iron work of the structure was erected on Messrs. Forrester and Co.'s premises, at Liverpool, with the view of attaining the accurate fitting of the parts, and of testing its strength. While at its full height, with the exception of the piles at the bottom and the lantern at the top, but with the joints merely bolted together, it was exposed, in September and October, 1860, to two gales of wind of the registered force, respectively, of 20·5 lbs. and 24·3 lbs. per sq. ft. There was no appearance of any straining of the joints, and a careful examination failed to discover any swaying movement at the top, though there was a sensible vibration. Since its erection on the reef it had been subjected to two severe gales (in June 1862, and in January 1863), with similar results, for although the top of the building had vibrated, there were no symptoms of straining having occurred.

The general principles of the construction of the Dædalus lighthouse were the same as those of the Ushruffee, with such modifications as its smaller size demanded; thus there were only twelve instead of

eighteen piles, and the dimensions of the parts of the frame-work were the same as for the upper piers of the Ushruffee. The building was stated to be very stiff, scarcely any vibration being perceptible under a strong breeze.

The lanterns were of the same construction for the three lighthouses. Those for the Ushruffee and the Zafarana, being for first-order lights, were identical in every respect. That for the Dædalus being for a second-order light, was of reduced size. In construction they were similar to those generally manufactured for the Trinity Corporation, but with special arrangements for mitigating the powerful effects of the sun. At the suggestion of Professor Faraday, a wind-guard was substituted for the ordinary revolving vane and cowl. The lanterns and light apparatus were furnished by Messrs. Wilkins and Co., the optical portion having been manufactured by Messrs. Chance Brothers, whose improvements in lighthouse illumination deserved special notice. The Zafarana and the Dædalus were fixed lights, while the Ushruffee had a revolving light frame.

The whole of the materials of the two iron lighthouses, and of the three lanterns and light apparatus, were, with some trifling exceptions, despatched from Liverpool within ten months from the date of the author receiving instructions to proceed to survey the sites, at a distance of nearly 3000 miles from Great Britain.

As the structures were designed with a special view to the peculiar circumstances of the sites upon which they were to be erected, it was considered desirable to give some account of the operation of erection. The Peninsular and Oriental Steam Packet Company granted, gratuitously, the services of the "Union," a screw steamer of 300 tons, and 60-horse-power, the Egyptian government paying for all wages, stores, and coal. The materials arrived at Alexandria on the 12th of November, 1860, but it was not until the 20th of December following that they were all received at Suez, and placed on board the "Union," which then sailed for the Ushruffee reef. The expedition thus commenced was, unfortunately, not successful. The causes of the failure were given at length in the Paper, but it would be sufficient to state the results of the season's labor, which lasted three months. The piles were erected on the reef and their heads were connected by the bottom iron frame. The whole of the iron-work was landed, and laid out in order, upon one of the neighboring islands. This was not originally intended, as the plan decided upon was to moor the ship as near as possible to the reef during the progress of the works, and to land and sort the materials upon the concrete base of the lighthouse itself. After a full inquiry into the circumstances which had led to this failure, the author was instructed to make arrangements for a new expedition, and he readily assented to the suggestion that he should remain on the spot until the operations as to which difficulty had to be anticipated were completed. The permanent superintendence was intrusted to the late Mr. C. W. Scott (Assoc. Inst. C.E.), Captain W. Kirton being in command of the "Union." As the materials had been landed on the Ushruffee Island, it was determined to form a land establishment for the

working party there rather than to quarter the men on board. This left the steamer free to carry a working party to the Dædalus, without interfering with the operations on the Ushruffee. The staff was re-organized, and the list of plant and of materials revised; but owing to several causes the operations were not resumed on the Ushruffee until the 8th November, 1861. The first step was to form the shore establishment. This occupied three weeks, owing to the want of skill of the native carpenters in getting the huts ready for occupation. During this time, however, some progress had been made at the lighthouse. The caisson of iron plates to enclose the concrete base had been set up, and about 200 tons of gravel had been placed upon the reef, where it was exposed to a wash sufficient to remove some of the clayey particles. The process of depositing the concrete was then commenced, the plan adopted being to deposit it upon sheets of tarpaulin, which sunk with the weight, and protected the soft material from the action of the water, until a mass of several tons was collected. When the whole space was covered in this way up to above low-water mark, the remainder was deposited, as the state of the tide allowed, until the whole height of 5 feet from the surface of the coral was complete. The first half of the concrete was formed of 6 measures of gravel to 1 of Portland cement, mixed in the lighters moored alongside the caisson. The second half was formed of lime, puzzuolano, and broken stone, in the manner usually practised in the country. The latter was mixed dry at Suez, and was wetted on being deposited.

When the success of the process of depositing the concrete was well assured, the author turned his attention to the Dædalus, which was reached on the 26th of December. A site for the lighthouse was chosen near a small sank-bank of triturated coral, as it was determined to use the sand for the concrete, and as it was also convenient for beaching boats, &c. The surface of this reef was very irregular, there being numerous hollow places, varying from 1 ft. 6 in. to 2 ft. in depth. A four-legged shears was set up on the intended site, and a platform fixed upon it at the level of the underside of the pile collars. Upon this platform were bolted together the plates forming the polygon to complete the inner circle of piles. The six piles were then successively raised on end, and the collars were bolted to the polygon. When the six piles were fixed, the original stage was removed, and a new one was formed to receive in a similar manner the outer polygon. This having been fixed in place, and the two polygons connected by the radiators, the outer piles were raised. The caisson plates were then set up, being first bolted together and then partially riveted. The whole of these operations occupied seven days and a quarter, the staff employed consisting of four workmen, and parties of from six to eight men of the crew. The lighter was then moored upon the reef, and the steamer proceeded to Ushruffee, whence it returned with 50 tons of cement and twenty Arab laborers, under a native foreman, for depositing the concrete, and having a second lighter in tow. The concrete here used consisted of $3\frac{1}{2}$ measures of coral sand to 1 measure of cement. The first operation was to fill up the holes between the coral lumps with coal

bags filled with concrete, so as to make an even surface to lay the tarpaulins upon. The deposit was then carried on in the same manner as at the Ushruffee. The quantity of cement above alluded to was only sufficient to complete three-fourths of the required height of the block. This occupied just eight days, and then the author returned to Ushruffee, and finding five tiers of that lighthouse erected and partly riveted, he handed over the entire charge of both works to Mr. Scott, who shortly after proceeded with a party of four mechanics, two riveters, four laborers, and ten Arabs, in all twenty, besides the crew, to the Dædalus. With these, in twenty-six days—the work being carried on only on twenty-one days—the whole frame-work was erected and riveted together, two floors and the water-tank were completed, and the lower room was enclosed. Two mechanics and four seamen were then placed in the building, with provisions and water, to continue the work, and the "Union," with Mr. Scott, and the remainder of the working party, returned to Ushruffee. Thus in thirty-seven working days, the main portion of the building, now 57 feet in height, was so far finished as to be habitable for a party sufficient to complete the remaining details. Had the ship been of larger burthen, it was believed that these thirty-seven days might have been continuous, and that the whole would have been accomplished during an absence of about seven weeks from Suez. The author referred in terms of the highest praise to the manner in which what might be termed the nautical part of the undertaking had been carried out by Captain Kirton. Subsequently the materials for the lantern and the lighting apparatus were deposited in the building, and afterwards one leading mechanic, two laborers, and five seamen, completed the work between November, 1862, and the 1st of February, 1863, when the light was exhibited.

At the last mention of the Ushruffee the concrete base had been completed, and five out of eleven tiers of framing had been erected. During the absence of Mr. Scott and his party at the Dædalus, a European boat's crew of six men was engaged in conveying the remainder of the materials to the reef and in sorting them there. On the return of the working party the erection was rapidly proceeded with, in the face of much difficulty, from almost constant high northerly winds. The time actually taken in erecting the skeleton frame-work, 106 feet in height, was two months, and the riveting was completed within three months. The two succeeding months were occupied with the erection of the lantern and lighting apparatus, and completing the details of the building, and on the 1st of July, 1862, the light was first exhibited.

In connexion with this undertaking the profession has to regret the loss of a very promising young member, Mr. C. W. Scott, who towards the close of the operations was attacked with symptoms which developed the seeds of a disease of long standing, under which he succumbed after an interval of five months.

With regard to the cost, a mere statement of the total amount expended upon the two lighthouses, £55,211 in all, would convey an erroneous impression, unless accompanied by an explanation. The cost of the whole as an engineering work, independently of the em-

ployment of the steamer, might be taken at £32,079 including all contingencies. Supposing the reef to have been within a boating distance, say 1½ mile and ½ mile from Suez, if the steamer had been equipped at Suez, and had been continuously employed, then, on this supposition, the cost might have been £42,082. The remaining expenditure, £13,029 was entirely exceptional, arising mainly from the steamer being equipped at Bombay. Proc. Inst. Civil Eng., Nov. 10, 1863.

For the Journal of the Franklin Institute.

Trussed Arch.

By De Volson Wood, Prof. of C. E. University of Michigan.

The problem which I propose to discuss may be stated as follows:

Let the arch of the Truss be a parabola, or if it be polygonal, let the vertices of the polygon be in a parabola; the tie which joins the ends of the arch be horizontal; all the parts of the truss be reduced to mathematical lines, and the joints perfectly flexible. Let the load over any part of the truss be uniform—or, what is better, let the weights upon the joints equal each other.

It is well known that for an uniform load over the whole length of a parabolic arc, there are no strains in it but compression (or tension), and hence, if the load be above the arch there will be no strains upon the ties and braces; and if the load be below, the ties will simply sustain the total load; hence the strains upon the several parts are easily computed. I will, therefore, proceed to the case of a partially loaded truss. Let the horizontal tie be divided into equal parts by the trussing, and let each part be called a bay.

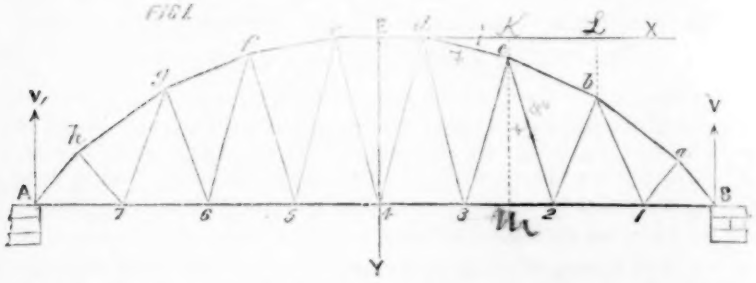
Let N = total number of bays in the horizontal tie,
n = the number of a bay which corresponds to the number of a brace or pair of braces,
F = the force of compression in the arch at any point,
F_1 = H = horizontal force in the tie,
F_2 = the strain on a brace or tie in the truss,
i = the inclination of the arch to the horizontal,
θ = the inclination of a brace, or tie, to the vertical,
D = greatest depth of the truss = distance from the vertex of the parabola to the horizontal tie,
h = depth of the truss at any point,
l = length of bay,
p = one of the equal weights which constitutes the load,
V and V_1 = vertical re-actions of the supports, and let n be counted from the V support,
x be horizontal and positive towards V,
y be vertical and positive downwards, then if θ is on the right of y it will be positive; if on the left, negative.
x', y' be the co-ordinates of c,
x'', y'' be the co-ordinates of b,
$2p_1$ the parameter of the parabola.

For the equation of the arch we have,

$$x^2 = 2p_1 y \text{ or } \tfrac{1}{4}N^2 l^2 = 2p_1 D \quad \therefore 2p_1 = \frac{N^2 l^2}{4D} \text{ which gives}$$

$$x^2 = \frac{N^2 l^2}{4D} y \text{ or } y = \frac{4D}{N^2 l^2} x^2 \quad . \quad . \quad . \quad (1)$$

It can easily be shown that if the truss be uniformly loaded from any brace to the remote end, the strain upon the brace will be greater than if there be an additional uniform load between it and the near end. I shall therefore consider the case of such an uniform load.



First, take the case of triangular trussing as shown in Fig. 1. Let equal weights rest upon the joints *c*, *d*, *e*, *f*, *g*, and *h*, and none upon *a* and *b*. This will insure, as stated above, a greater strain on *c*2 than if *b* or *a*, or both were loaded with the same weights. Suppose now that a vertical section is made just at the right of *c*; said section will intersect *cb*, *c*2, and 3 2, and the strains in these bars must be in equilibrium with the forces between the section and B; in other words they must be in equilibrium with V_1, and since V acts vertically, we have the vertical components in *cb* and *c*2 equal V, and the horizontal components in the same bars equal the strain on 3 2, or equal H. Hence using the notation given above, we readily have

$$F \sin i + F_2 \cos\theta = V \quad . \quad . \quad . \quad (2)$$

$$F \cos i + F_2 \sin\theta = H \quad . \quad . \quad . \quad (3)$$

Multiply (2) by cos *i*, (3) by sin *i*, subtract and reduce gives

$$F_2 \cos\theta = \frac{V - H \operatorname{tang} i}{1 - \operatorname{tang}\theta \operatorname{tang} i} \quad . \quad . \quad . \quad (4)$$

This formula is general, whatever be the curve of the arch.

Calling *a* 1 *b* the first pair of braces (or ties) counting from B; let *b* 2 *c* be the n^{th} pair; then will

2 1 be the n^{th} bay; 3 2 the $(n+1)^{th}$ bay, and

$N - n$ = the number of loaded joints,

$\therefore (N-n)p$ = the total load on the truss,

Nl = A B = total length of truss,

$\frac{1}{2}(N-n)l$ = distance from the centre of the load to A,

Then by the principle of the lever we have

$$\text{V}\,\text{N}\,l=(\text{N}-n)\,p\,.\,\tfrac{1}{2}\,(\text{N}-n)\,l$$

$$\therefore\ \text{V}=\frac{(\text{N}-n)^2}{2\,\text{N}}\,p. \quad . \quad . \quad . \quad . \quad (5)$$

We also have from the figure,

$$\text{B}\,m=(n+\tfrac{1}{2})l$$

$$x'=\text{EK}=(\tfrac{1}{2}\,\text{N}-n-\tfrac{1}{2})l\ \therefore\ \text{By (1) we have } y'=\frac{\text{D}}{\text{N}^2}\,(\text{N}-2\,n-1)^2$$

$$x''=\text{EL}=(\tfrac{1}{2}\,\text{N}-n+\tfrac{1}{2})l \quad . \quad . \quad y''=\frac{\text{D}}{\text{N}^2}\,(\text{N}-2n+1)^2$$

$$\text{tang}\,i=\frac{y''-y'}{l}=\frac{4\,\text{D}}{\text{N}^2 l}\,(\text{N}-2\,n) \quad . \quad . \quad . \quad (6)$$

$$\text{tang}\,\theta=\frac{\frac{1}{2}\,l}{\text{D}-y'}=\frac{l\,\text{N}^2}{2\,\text{D}\left[\text{N}^2-(\text{N}-2\,n-1)^2\right]} \quad . \quad . \quad (7)$$

To find the tension in the bar 3 2, we take the origin of moments at c, and we readily have

$$\text{H}\,(\text{D}-y')=\text{V}\,(n+\tfrac{1}{2})\,l$$

$$\therefore\ \text{H}=\frac{\text{N}^2 l\,\text{V}}{2\,\text{D}\,(2\,\text{N}-2\,n-1)} \quad . \quad . \quad (8)$$

Substitute (5), (6), (7), and (8) in (4), gives

$$\text{F}_2\cos\theta=\frac{(\text{N}-n)^2\,p}{2\,\text{N}}\left[\frac{4n^2-1}{4n\,\text{N}-4n^2-1}\right]$$

$$=\frac{(\text{N}-n)}{2\,\text{N}}\,p\left[n-\frac{\text{N}-2n}{4n\,(\text{N}-n)-1}\right] \quad . \quad (9)$$

We see in (9) that when n is less than $\frac{1}{2}$ N the fraction in the parenthesis is negative; but when it exceeds $\frac{1}{2}$ N, it becomes positive, and observing that when it is greater than $\frac{1}{2}$ N, less than one-half the bridge is loaded, we have this peculiar result: the strain upon a tie or brace, is greatest when the truss is loaded between it and the nearer end. We may also observe, that in practical cases the omission of the fraction in the parenthesis, will not give an error of more than one-fifth the true value, and generally the error will be much less. Hence we have approximately

$$\text{F}_2\cos\theta=\frac{(\text{N}-n)\,np}{2\,\text{N}}\ * \quad . \quad . \quad . \quad (10)$$

If (10) were true we observe that the strains on any brace will be the same if the load extend from it to either end.

It is easy to show, geometrically, that the vertical components of the strains on each of the braces which constitute a pair, as has been designated, are equal. To give a further application of the analysis, I will prove it by equation (4). Now let a vertical section be made, just at the left, but infinitely near b. The section will cut $b\,2$, be, and

* Bow in his excellent Treatise on Bracing, gives this as the *exact* formula.

12. Tang i and V, will remain the same, but tang θ is negative and equal $\frac{\frac{1}{2}l}{D-y''}$; . . . . (10′)

and to find H we have $H(D-y'') = V(n-\frac{1}{2})l$.

$$\therefore \quad H = \frac{\frac{1}{2}(2n-1)l}{D-y''} V \qquad . \quad . \quad . \quad (11)$$

These in (4) give

$$F_2 \cos\theta = V \frac{1 - \frac{2n-1}{D-y''} \cdot \frac{2D}{N^2}(N-2n)}{1 + \frac{2D}{(D-y'')} \cdot \frac{(N-2n)}{N2}}$$ which reduced gives

$$F_2 \cos\theta = \frac{(N-n)^2}{2N} p \quad \left[\begin{matrix} 4n^2-1 \\ 4nN-4n^2-1 \end{matrix}\right]$$ the same as before.

But the strains on the braces of a pair will not be equal, for they are unequally inclined. To find F_2, we find θ from (7) and use it in (9).

Example.—Let $N=8$ and $D=l$.

To show more clearly the value of the fraction in the parenthesis, Eq. (9), I will keep it separate in the following table:

No. of the pair of braces, or $n=$	Vertical component of the strains on the n^{th} pair; or $F_2 \cos\theta$, Eq. (9.)	Inclination of the braces; or θ, Eq. (7.)	Values of $\cos\theta$.	Numbers in the second column divided by those in the fourth; or, F_2.
0	$0 + \frac{5}{2}$ $p = 4{\cdot}000\,p.$	*Ba*, 64°53′	0·4245	9·422 p
1	$(\frac{7}{16} - \frac{7}{72})$ $p = 0{\cdot}3403\,p.$	*a*1, 64°54′	0·4245	0·802 p
		*b*1, 39°22′	0·7731	0·440 p
2	$(\frac{3}{4} - \frac{3}{9 4})$ $p = 0{\cdot}7189\,p.$	*b*2, 39°22′	0·7731	0·928 p
		*c*2, 30°11′	0·8644	0·831 p
3	$(1\frac{5}{16} - 4\frac{5}{72})$ $p = 0{\cdot}9270\,p.$	*c*3, 30°11′	0·8644	1·072 p
		*d*3, 26°55′	0·8916	1·038 p
4	$p = 1{\cdot}0000\,p.$	*d*4, 26°55′	0·8916	1·121 p
		*e*4, 26°55′	0·8916	1·121 p
5	$(1\frac{5}{16} + 4\frac{3}{72})$ $p = 0{\cdot}9438\,p.$	*e*5, 26°55′	0·8916	1·057 p
		*f*5, 30°11′	0·8644	1·090 p
6	$(\frac{3}{4} + 9\frac{1}{4})$ $p = 0{\cdot}7606\,p.$	*f*6, 30°11′	0·8644	0·879 p
		*g*6, 39°22′	0·7731	0·998 p
7	$(\frac{7}{16} + 7\frac{1}{2})$ $p = 0{\cdot}4514\,p.$	*g*7, 39°22′	0·7731	0·583 p
		*h*7, 64°54′	0·4245	1·060 p
8	$p = 0{\cdot}000\,p.$			

We may readily conceive these strains to be produced by an uniform load moving without shock over the truss from B to A; and the same strains in a reverse order may be produced by a movement in the opposite direction.

When N is even we may have $n = \frac{1}{2}N$, which in (9) gives $F_2 \cos\theta = \frac{1}{8}Np$.

Next suppose the load on the horizontal tie. This is the more na-

tural place for the surcharge. In this case the vertical force sustained by each pair when they are all equally loaded, is p. But if only a portion of the truss be loaded, equation (9) will not apply, as may be seen from the following statements. To produce the greatest strain on $c3$, we unload joints 1 and 2, and load 3, 4, 5, 6, and 7; and calling the bay $2-1$, the n^{th}, the load will be $(N-n)p$; and the centre of the loading will be $\frac{1}{2}(N-n+1)\,l$ from A; hence, to find V we have

$$V \cdot Nl = \tfrac{1}{2}(N-n)(N-n+1)P.$$

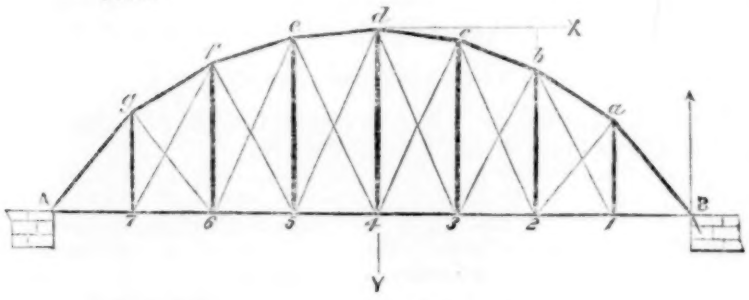
$$\therefore\ V = \frac{(N-n)(N-n+1)P}{2N}. \qquad . \qquad . \qquad . \qquad (12)$$

If joint 2 be loaded, the vertical force on $c2$ will not be the same as on $b2$, but we may find it on $b2$ by making a section just to the left of b; and substitute in (4) the values of (6), (10′), and (12). But we observe that these values are all the same as those before used, except V; hence we have at once, for the strain on the first of the n^{th} pair,

$$F_2 \cos\theta = \frac{(N-n)(N-n+1)}{2N}\, p \left[\frac{4n^2-1}{4nN-4n^2-1}\right] \qquad (13)$$

Next consider panel trussing as shown in Fig. 2, and let the load be upon the lower chord, and let the bays in the lower chord be of equal lengths. It will make some difference in the strains whether they be resisted by ties or braces.

FIG 2.



First consider braces.

Let x' and y' be the co-ordinates of c.

x'' y'' be the co-ordinates of b.

3 2 be the n^{th} bay, and call $c2$ the n^{th} brace, and

$c3$ the n^{th} tie. Suppose the load is on from A to 3, and off from B to 2, including 2; then the load is $(N-n)p$; and V the same as (12). The equation of the curve is given by (1), hence we have

$$x' = (\tfrac{1}{2}N - n)l\,,\ y' = \frac{D}{N^2}(N-2n)^2$$

$$x'' = (\tfrac{1}{2}N - n + 1)l\,,\ y'' = \frac{D}{N^2}(N-2n+2)^2$$

$$\text{tang } i = \frac{y'' - y'}{l} = \frac{4\text{D}}{l\text{N}^2}(\text{N} - 2n + 1) \quad . \quad . \quad . \quad (13a)$$

$$\text{tang } \theta = \frac{l}{\text{D} - y'} = \frac{l\text{N}^2}{4\text{D}n(\text{N} - n)} \quad . \quad . \quad . \quad (14)$$

Now conceive a section made just at the right, but infinitely near c, so as to cut cb, $c2$, and 3 2; then will equation (4) be applicable. It cuts $b3$, but it is not in action when $c2$ is. To find H, we have by an equation of moments,

$$\text{H}(\text{D} - y') = \text{V}nl$$

$$\therefore \text{H} = \text{V}\frac{l\text{N}^2}{4\text{D}(\text{N} - n)}$$

These in (4) give by reduction

$$\text{F}_2 \cos\theta = \frac{(\text{N} - n)(\text{N} - n + 1)(n - 1)n}{n\text{N} - \text{N} - n^2 + 2n - 1} \cdot \frac{p}{2\text{N}} = \frac{(\text{N} - n)n}{2\text{N}} p \quad . \quad (15)$$

This is a maximum for $n = \frac{1}{2}\text{N}$, for which it equals $\frac{1}{8}\text{N}p$; hence, if there are less than N bays the central brace will not be strained as much as for half the truss loaded as for the whole truss loaded: if $\text{N} = 8$, it will be strained the same; if greater it will be strained more for half the truss loaded than for the whole loaded. We also see that for the partial load the central ones are strained more than the end ones. The formula does not give the vertical strain on $\text{D}a$; for it is really $\text{V} = \frac{1}{2}(\text{N} - 1)p$; but for $n = 1$, (15) gives $\frac{\text{N} - 1}{2\text{N}} p$. The reason of this failure will be found by observing that in making the reduction of (15), a factor $(n - 1)$ is cancelled in both terms of the fraction, which factor is 0 for $n = 1$, which would make the fraction $\frac{0}{0}$.

Example.—Let $\text{N} = 8$. D has disappeared in the reduction, but it must be known to get θ. Let $\text{D} = 2l$. We have

No. of the brace, or $n =$	Vertical component of the strain on the n^{th} brace, or $\text{F}_2 \cos\theta$; eq. (15)	Inclination of the braces, or θ, eq. (14)	Values of $\cos\theta$.	Strains on the n^{th} brace, or F_2 eq. (15)
1 or 7; or g 6	$\frac{7}{16}p$	48°48′	0·6587	0·6641 p
2 or 6; or b1 or f 5	$\frac{13}{16}p$	33°41′	0·8321	0·9013 p
3 or 5; or c2 or e4	$\frac{15}{16}p$	28° 4′	0·8824	1·0624 p
4 ; or d3	1 p	26°34′	0·8944	1·1182 p

Although the braces which we have considered, at the rear end of the load incline towards the load, yet they must incline both ways as in the figure to completely brace the truss. For this partial load, the vertical strain on a1, is the same as on b1; and if the load extends

from 3 to A, the vertical forces on $c2$ and $b2$ are equal. Similarly for the other pairs; hence, observing the numbers in the second column of the preceding table, and we have for the actual strains on the vertical ties taken in their order from either end, when the load extends from the tie to the other end: $\frac{13}{16}p$, $\frac{15}{16}p$, p, $\frac{15}{16}p$, $\frac{13}{16}p$, $\frac{7}{16}p$.

Now suppose there are ties instead of braces, in the panels. Making the section at b and it will cut the acting bars cb, $b3$, and 3 2. When it is loaded from 3 to A, $c2$ will not act.

$$\text{tang}\,\theta = -\frac{l}{\text{D}-y''} \quad . \quad . \quad . \quad (16)$$

$$\text{and H} \;.\; (\text{D}-y'') = \text{V}\,(n-1)\,l$$

$$\therefore\ \text{H} = \frac{\text{V}\,(n-1)\,l}{\text{D}-y''} = \frac{\text{V}\,l\,\text{N}^2}{4\,\text{D}\,(\text{N}-n+1)}$$

$$y'' = \frac{\text{D}}{\text{N}^2}(\text{N}-2n+2)$$

V is given in (12) and tang i in (13a); these substituted in (4) give

$$\text{F}_2\cos\theta = \text{V}\frac{1-\frac{(n-1)l}{\text{D}-y''}\;.\;\frac{4\,\text{D}}{\text{N}^2 l}(\text{N}-2n+1)}{1+\frac{l}{\text{D}-y''}\;.\;\frac{4\,\text{D}}{\text{N}^2 l}(\text{N}-2n+1)}$$

$$= \text{V}\frac{n-1}{\text{N}-n} = \frac{(\text{N}-n+1)\,(n-1)}{2\,\text{N}} \quad . \quad . \quad (17)$$

This formula also fails, for $n = \text{N}$, because, in making the final reduction, we dropped a factor, $\frac{\text{N}-n}{\text{N}-n}$, which for $n = \text{N}$ becomes $\frac{0}{0}$, but it should $= 0$. It is true for all the other ties.

If in (17) we write $n+1$ for n, we will have $(\text{N}-n)n$, which is the same as (15); hence, the vertical component of the strain on a brace, when braces are used, is the same as on the tie in the next panel, when ties are used; and as the inclinations, $c2$ and $c4$, for instance, are the same, the *actual* strains will be the same. Hence, referring to the preceding table, we have $\frac{7}{16}p$ for the vertical strain on the *second* tie (or $a2$); $\frac{13}{16}p$ on the *third* tie (or $b3$), &c.

The general principles of the methods here used are applicable to those cases in which the bays of the lower chord are not equal; but in such cases we cannot obtain as symmetrical expressions as those here found.

Railroad Cuttings and Embankments.—Side Depths and Side Stakes. By Oliver Byrne, C.E.

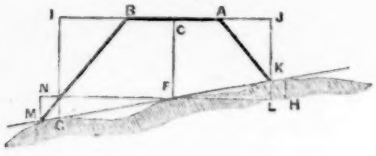
From the Lond. Civ. Eng. and Arch. Jour., Feb., 1864.

(Continued from page 152.)

In an embankment (Fig. 7), given the breadth of the roadway AB = 32 feet; the height CF = 18 feet; the side slopes as 1 to $\frac{2}{3}$ (BI : ID : : 1 : $\frac{2}{3}$); the fall of the surface F to M = 1 in 26$\frac{1}{2}$ (FN : NM : 26$\frac{1}{2}$: 1); the rise of the surface from F to K to be

the same as the fall, which is very often the case. Required the horizontal distances FN and FL, where the surface of the ground will meet the rise and slopes of the road.

Fig. 7.



$$DF = \frac{32}{2} + \frac{3}{2} \times 18 = 43 = FH.$$

$$26\tfrac{1}{2} \times \tfrac{2}{3} = 17\tfrac{2}{3}$$
$$\text{take} \quad 1$$
$$16\tfrac{2}{3}$$

$$\frac{43}{16\frac{2}{3}} = \frac{129}{50} = 2{\cdot}58$$

43 *plus* 2·58 = 45·58 = FN.

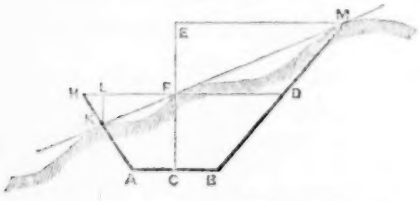
$$\frac{43}{18\frac{2}{3}} = \frac{129}{56} = 2{\cdot}3, \text{ and}$$

43 *minus* 2·3 = 40·7 = FL.

With embankments the rise answers to the fall in cuttings, by inverting Fig. 3 (*ante* page 146) it becomes Fig. 4; hence the rule given for cuttings is easily made to answer for embankments.

In a cutting, Fig. 8, given the breadth of the roadway AB = 28 feet; the height CF = 20 feet; the ratio of the side slopes 1 : $\frac{1}{2}$; the inclination of the surface of the ground at the cross-section, taken by a theodolite = 14°, that is, the angle MFD = HFK = 14°. Required the horizontal distance EM and FL, where the surface of the ground meets the side slopes.

Fig. 8.



90° — 14° = 7°.

The natural tangent of 76° = 4·010781, hence the rise and fall of the slope of the surface of the ground at the cross-section may be taken as 4·01 to 1,

$$HF = \frac{28}{2} + \frac{2}{1} 20 = 54 = FD.$$

$$4{\cdot}01 \times \tfrac{1}{2} = 2{\cdot}005$$
$$\text{Subtract} \quad . \quad 1{\cdot}000$$
$$1{\cdot}005$$

$$\frac{54}{1{\cdot}005} = 53{\cdot}73$$

Add . 54·00 half-breadth.

EM = 107·73 feet.

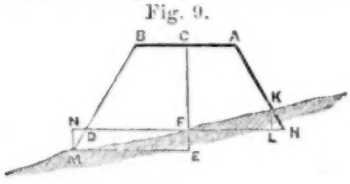
Again,

$$4{\cdot}01 \times \tfrac{1}{2} = 2{\cdot}005$$
$$\text{Add} \quad . \quad 1{\cdot}000$$
$$3{\cdot}000$$

$$\frac{54}{3{\cdot}005} = \begin{matrix} 54{\cdot}00 \text{ half-breadth.} \\ 17{\cdot}97 \text{ take} \end{matrix}$$
$$\text{FL} = 36{\cdot}03 \text{ feet.}$$

In an embankment (Fig. 9), given the breadth of the roadway AB = 30 feet; the height CF = 12 feet; the ratio of the side slopes $1 : \frac{3}{4}$; the elevation or inclination of the surface of the ground in the direction of the cross-section = 3°, that is, angle KFH = DFM = 3°. Required the horizontal distances EM, FL, where the surface of the ground meets the side slopes.

Fig. 9.



$90° - 3° = 87°$; tan $87° = 19{\cdot}081137$.

Hence the rise and fall of the surface from the centre stake F may be represented by the ratio 19·08 to 1.

$$\text{HF} = \frac{30}{2} + \frac{4}{3} \times 12 = 31 = \text{FD}.$$
$$19{\cdot}08 \times \tfrac{3}{4} = 14{\cdot}31$$
$$\text{Subtract} \quad . \quad 1{\cdot}00$$
$$13{\cdot}31$$

$$\frac{31}{13{\cdot}31} = 2{\cdot}33$$
$$31{\cdot}00 = \text{FD}$$
$$33{\cdot}33 = \text{EM}$$

Again,

$$19{\cdot}08 \times \tfrac{3}{4} = 14{\cdot}31$$
$$\text{Add} \quad . \quad 1{\cdot}00$$
$$15{\cdot}31$$

$$\frac{31}{15{\cdot}31} = 2{\cdot}03$$
$$31{\cdot}00 = \text{FH}$$
$$\text{Difference} \quad 28{\cdot}97 = \text{FL}.$$

The simplicity of this plan of putting down side stakes is apparent, and the formula from which it is deduced is easily remembered.

$$\text{HL} = \frac{d}{ne+1}; \quad d = \text{FH}.$$

$$\text{DN} = \frac{d}{nt-1}; \quad d = \text{FD}.$$

It should be remembered that in the ratio 1 to n, 1 represents the base and n the perpendicular of the side slopes. In the ratio t to 1, t represents the base, and 1 the perpendicular rise in the case of a cutting, and *vice versa* in the case of an embankment (see Figs. 7 and 8). The ratio e to 1, e represents the base and 1 the perpendicular.

To set out the widths when the surface of the ground is laterally sloping, and when the cross-section consists partly of cutting and partly embanking. Let K, A, QMB, Fig. 10, be the cross-section of a railroad, consisting partly of a cutting QMB, and partly of an embankment AQK. Let t = AB = DH, the bottom width, F the centre stump, FC = h the depth of the cutting, KM the sloping surface of the ground. First, suppose the embankment AKQ to occupy less than half the bottom width, as from A to Q, Fig. 10. And further, suppose the ratio of the slope of the earth on both sides of the centre stake F, to be represented by the same ratio t to 1; that is,

$$\text{FN} : \text{NM} :: t : 1, \text{ or } \text{FL} : \text{LK} :: t : 1.$$

Yet the reasoning upon which the practical rule is founded will apply to two different slopes of ground, from the centre stake F, as in the former case. When the slope of the ground is known, or the ratio $t : 1$ is determined, then the point Q where the slope meets the base is readily found; for

$$1 : t :: \text{FC} : \text{CQ}. \quad \text{Or } \text{QC} = ht.$$

That is, if the height h multiplied by t be less than AC, half the breadth of the roadway, the work will be at the cross-section part cutting and part embankment.

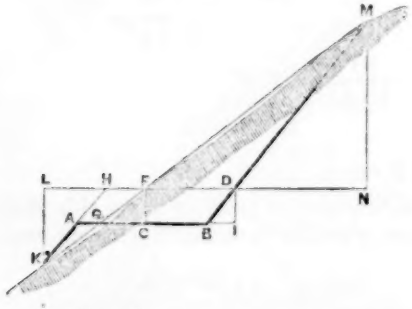
Let the side slopes be represented by the ratio $1 : n$, that is,

$$\text{BI} : \text{ID} = \text{DN} : \text{NM} = \text{HL} : \text{LK} = 1 : n.$$

Put DN = x, and HL = y.

The horizontal half-breadth FD, through F, to meet the slope of the cutting, is found as in the former investigation, where the slope of the ground does not meet the roadway at either side of F.

Fig. 10.



$$\text{FD} = \frac{b}{2} + \frac{1}{n} \times h, \text{ which put} = d.$$

The horizontal half-breadth FH, through F, to meet the slope of the embankment KH, is easily found when FD is known, for

$$\text{HD} = \text{AB} = b, \text{ and } \text{HF} = \text{HD} - \text{FD} = b - \left(\frac{b}{2} + \frac{h}{n}\right) = \frac{b}{2} - \frac{h}{n}$$

which put $= \delta = \text{HF}$.

$$1 : n :: x : nx = \text{NM}.$$

Also, $t : 1 :: d + x : \dfrac{d+x}{t} = \text{NM}$; $\therefore nx = \dfrac{d+x}{t}$, or $x = \dfrac{d}{nt-1}$

This result is exactly the same as that given before, for the increase of horizontal breadth in the case of a rise in cutting, or a fall in embanking.

$$1 : n :: y : ny = \text{KL};$$

Again, $t : 1 :: \delta + y : \dfrac{\delta+y}{t} = \text{KL}$; $\therefore ny = \dfrac{\delta+y}{t}$, or $y = \dfrac{\delta}{nt-1}$

which is a similar expression to that given for x; the only difference is that $\delta = \text{HF}$ is put in the place of $d = \text{FD}$.

Example.—Let AB $= b = 28$ feet; FC $= h = 4$ feet; the side slopes 1 : 2 (BI : ID :: 1 : 2); the cross slope of the ground 13 to 1 (FN : NM :: 13 : 1). Required the horizontal distances FN and FL where the slopes meet the surface.

$$\text{FD} = \frac{28}{2} + \tfrac{1}{2} \text{ of } 4 = 16 = d.$$

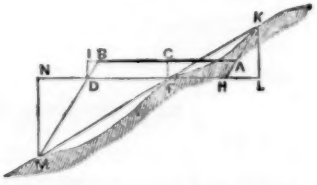
$$\text{FH} = 28 - 16 = 12 = \delta.$$

Since $n = 2$, and $t = 13$, $\therefore \dfrac{16}{2 \times 13 - 1} = \cdot 64$, and $\dfrac{12}{2 \times 13 - 1} = 48$.

$\therefore$ $16 \cdot 64 = \text{FN}$ $\qquad$ $12 \cdot 48 = \text{FL}$.

Example.—In Fig. 11, the embankment MBQ occupies more than half the bottom width, as from B to Q. Let AC $=$ CB $= 14$ feet; FC $= 4$ feet.

Fig. 11.



FL : LK :: 13 : 1, $\qquad$ HL : LK :: 1 : 2;

as in the last example, required the horizontal distances from F to L and from F to N.

$$\text{FD} = \frac{28}{2} + \tfrac{1}{2} \times 4 = 16 = d,$$

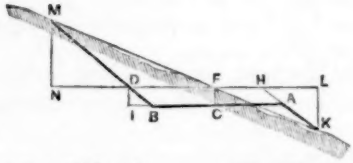
$$\text{FH} = 28 - 16 = 12 = \delta.$$

Since $n=2$, and $t=13$, $\therefore \frac{16}{2\times13-1}=64$, and $\frac{12}{2\times13-1}=\cdot48$;

Hence FN = 16·64, and FL = 12·48 feet.

Example.—In Fig. 12 the embankment AQK occupies less than half the bottom width from Q to A. Let AC = CB = 14 feet; FC = 4 feet;

Fig. 12.



FL : LK : : 13 : 1; BI : ID : : 1 : 2.

Required the horizontal distances from F to L, and from F to N.

$$FD=\frac{28}{2}+\tfrac{1}{2}\times4=16=d.$$

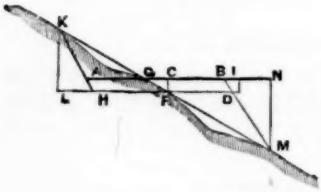
$$FH=28-16=12=\delta.$$

$$\therefore \frac{16}{2\times13-1}=\cdot64, \text{ and } \frac{12}{2\times13-1}=\cdot48,$$

FN = 16·64 and FL = 12·48 feet.

Example.—In Fig. 13, the embankment QBM occupies more than half the bottom width, from Q to B. Let AC = CB = 14 feet. FC = 4 feet.

Fig. 13.



FL : LK : : 13 : 1;

HL : LK : : 1 : 2.

Required the horizontal distances from F to L and from F to N.

$$FD=\frac{28}{2}+\tfrac{1}{2}\times4=16=d.$$

$$FH=28-16=12=\delta.$$

$$\left.\begin{aligned} DN=x&=\frac{d}{nt-1}=\cdot64\\ HL=s&=\frac{\delta}{nt-1}=\cdot48\end{aligned}\right\}\text{ as in the foregoing examples.}$$

FN = 16·64 and FL = 12·48 feet.

By comparing the figures 10, 11, 12, and 13, and observing how the formulas $x=\frac{d}{nt-1}=$ DN, and $y=\frac{\delta}{nt-1}=$ HL, may be applied in each possible case, the setting out of side stakes, when part of the cross-section is a cutting and part an embankment, becomes easy.

MECHANICS, PHYSICS, AND CHEMISTRY.

For the Journal of the Franklin Institute.

On the Power requisite for the Propulsion of Steam Vessels.

By D. M. Greene, C. E., 2d Asst. Eng. U.S.N.

This problem, like that of determining the relations between the temperature, density, and volume of steam, seems never to have been satisfactorily solved: indeed, it is believed that the impracticability, if not the impossibility, of solutions based upon purely theoretical considerations, is generally conceded.

As, in the case of steam, the formulæ in use are based upon experimental results, so in the case under consideration, we must satisfy ourselves, for the present, at least, with an empirical formula, carefully deduced from the performances of steam vessels. Complete and reliable data are available, for this purpose, in the steam logs of vessels belonging to our navy.

Hitherto, it is believed to have been the custom, generally, to employ the formula given by Bourne, in his work on "The Steam Engine;" which is

$$HP = CAV^3; \quad . \quad . \quad . \quad (1)$$

in which

HP = the total horse power developed by the engines.

A = midship section, in square feet.

V = speed, in knots, per hour.

C = a constant for vessels of similar model;— different values of C being used for vessels of different model.

Solving (1) with respect to C, we have

$$C = \frac{HP}{AV^3}.$$

Substituting in this expression the values of HP, A and V^3, for any vessel, the corresponding value of C, for vessels of like model, is found.

The general principle involved in the foregoing formula, may be briefly stated, thus:—*The resistance, opposed by a liquid, to the motion of a solid through it, varies as square of the velocity, and as the midship section of the body; and the work expended, in overcoming this resistance, during a unit of time, varies as the cube of the velocity, and as the section.*

Hence the power, absolutely, would be the product of the cube of the speed, into the midship section, multiplied by the constant C.

That the formula, in question, is defective, may be inferred, from the fact that the *actual* performances of steam vessels, rarely ever agree, even approximately, with the *estimated* performances.

The defect seems to be,

1st. That no account is taken of the fact, that a very considerable portion of the total power of the engines,—amounting, in marine engines, to from one-eighth to one-fifth, and varying simply as the speed and area of piston,—is expended in overcoming the back-pressure in the cylinder, together with the friction of the engine itself; and,

2d. That too much importance is attached to the differences in model, as regards fullness, or sharpness; while the great influence of *immersed surface* is not recognised.

To illustrate the force of the last objection, let us take the extreme case of a cylindrical solid, having a diameter of ten feet, its axis vertical, and drawing ten feet: the immersed surface will thus be 392·7 square feet. Next, suppose the form changed in such a manner, as to make the horizontal section of the solid take the form of two isosceles triangles joined at their bases; the draft and displacement remaining the same. Then, if the length be 31·4 feet, and the breadth (beam) 5 feet, the immersed surface will be nearly 720 square feet.

It must be clear, therefore, that while an increased length and sharpness is attended by a diminution of resistance due to itself, there is at the same time an increase of immersed surface, which acts prejudicially to the motion of the vessel; and, moreover, that when the increased resistance due to the increase of immersed surface, becomes equal to the diminution of resistance, due to increased sharpness, any further increase in length and sharpness, for a given displacement, will be attended by an absolute increase of resistance. Unfortunately, we are as yet, unable to estimate correctly, the effect of immersed surface upon the resistance, or to fix the limit to the ratio, of length to breadth, which will insure the best results: it is believed, however, that in some instances, this limit has been reached, if not exceeded.

In the construction of an empirical formula, for the purpose stated, we shall make use of the performances of vessels, some of which have lines of more than average fullness, together with one (*Niagara*) which has lines of more than ordinary fineness. It will be assumed, that *within the limits of practice*, the difference in resistance due to difference in model—when compared with the difference in resistance due to a slight variation in speed—may be neglected without considerable error. The results will show how fully we are justified in making this assumption.

In addition to the notation already used,

Let D = displacement in tons.

l = length in feet.

C_1 = constant, depending upon the power P_1, expended in overcoming the back and friction pressures.

C_2 = constant, depending upon the power P_2, usefully applied to the shaft, together with the additional friction due to that power.

Then, since P_1 varies as the speed, and assuming for convenience, that it varies also as the midship section, we have

$$P_1 = C_1 A V, \quad . \quad . \quad . \quad (2)$$

Similarly $P_2 = C_2 A V^3$. . . . (3)

In order to express A, in terms of D, we have, from the relations between similar surfaces and solids, and their homologous dimensions

$$A \propto l^2. \quad \therefore \quad l \propto A^{\frac{1}{2}}$$

Also, $D \propto l^3$. $\therefore$ $l \propto D^{\frac{1}{3}}$

Whence $A^{\frac{1}{3}} \propto D^{\frac{1}{3}}$.

$\therefore$ $A \propto D^{\frac{2}{3}}$.

Substituting in (2) and (3), and collecting, we get

$$HP = c_1 D^{\frac{2}{3}} V + c_2 D^{\frac{2}{3}} V^3,$$
$$= D^{\frac{2}{3}} V (c_1 + c_2 V^2). \quad . \quad . \quad (4)$$

To find c_1 and c_2, we have from (2) and (3), after substituting $D^{\frac{2}{3}}$ for A,

$$c_1 = \frac{P_1}{D^{\frac{2}{3}} V}, \text{ and } c_2 = \frac{P_2}{D^{\frac{2}{3}} V^3}$$

respectively. Taking, now, the distribution of power, made by Chief Engineer Isherwood, U.S.N., in his works, we get in the cases of the different vessels named, the following results, viz:

Name of Vessel.	c_1	c_2
Merrimack, ...	·18184	·0047345
Wabash, ...	·14847	·0045799
Minnesota, ...	·15875	·0045725
Roanoke, ...	·13619	·0048133
Niagara, ...	·15067	·0047227
Mean values, .	·1552	·0046846

These values, substituted in (4), give, finally,

$$HP = D^{\frac{2}{3}} V(·1552 + ·0046846 V^2). \quad . \quad (5)$$

The close coincidence of the constants, for the *Niagara*, with those of the other vessels, will be observed; it seems to indicate that the limit of the ratio, of length to the breadth of beam, has been exceeded; or, that the power required to propel her, is as great as it would have been, had her model been similar to that of the other vessels named.

In (5), the part, $V(·1552 + 0046846 V^2)$

may be tabulated thus:

V.	C.	V.	C.
10	6·2366	16	21·6713
11	7·9424	17	25·6538
12	9·9574	18	30·1140
13	12·3097	19	35·0862
14	15·0273	20	40·5808
15	18·1385		

Then, in every case, we have

$$HP = D^{\frac{2}{3}} C; \quad . \quad . \quad . \quad (6)$$

C being taken from the table, to correspond with the required speed.

Example.—Required the total power of the engines which will develop a speed of 14 knots in a vessel whose displacement is 1000 tons.

From (6), $HP = 1000^{\frac{2}{3}} \times 15·0273$

$= 100 \times 15·0273$

$= 1502·7$

It should be remarked, in this connexion, that the formula is claimed to apply, only in the case of the maximum performance of the vessel; for, as the speed of the vessel is diminished, the value of P_2 will diminish faster than P_1; and hence the result given by the formula will be too small. The error due to this cause, however, on ordinary speeds, will not be very great.

By the aid of the formula (5), has been prepared, the following

TABLE OF POWERS DUE TO DIFFERENT DISPLACEMENTS AND SPEEDS.

D.	v = 10	v = 11	v = 12	v = 13	v = 14	v = 15	v = 16	v = 17
1000	624	787	996	1231	1503	1814	2167	2565
1100	665	839	1061	1312	1601	1933	2309	2734
1200	704	889	1125	1390	1697	2048	2447	2897
1300	743	937	1186	1466	1790	2161	2581	3056
1400	780	985	1246	1541	1881	2270	2712	3210
1500	817	1031	1305	1613	1967	2377	2840	3362
1600	853	1077	1362	1684	2056	2481	2965	3509
1700	888	1121	1418	1756	2140	2584	3087	3654
1800	923	1165	1473	1821	2224	2684	3207	3796
1900	957	1207	1528	1888	2305	2782	3324	3935
2000	990	1249	1581	1954	2385	2879	3440	4072
2100	1023	1291	1633	2019	2464	2975	3554	4207
2200	1055	1331	1684	2082	2542	3068	3666	4340
2300	1087	1371	1735	2145	2618	3160	3776	4470
2400	1118	1411	1785	2207	2694	3251	3885	4599
2500	1149	1450	1834	2268	2768	3341	3992	4725
2600	1179	1488	1883	2328	2841	3430	4098	4851
2700	1209	1526	1931	2387	2914	3517	4202	4974
2800	1239	1563	1978	2445	2985	3603	4305	5096
2900	1268	1600	2025	2503	3056	3689	4407	5217
3000	1298	1637	2071	2560	3126	3773	4508	5336
3100	1326	1673	2117	2617	3195	3856	4607	5454
3200	1354	1709	2162	2673	3263	3939	4706	5571
3300	1382	1744	2207	2729	3331	4020	4804	5686
3400	1410	1780	2251	2783	3398	4101	4900	5801
3500	1438	1814	2295	2838	3464	4181	4996	5914
3600	1465	1849	2339	2891	3530	4260	5090	6026
3700	1492	1883	2382	2945	3595	4339	5184	6137
3800	1519	1916	2425	2998	3660	4417	5277	6247
3900	1545	1950	2467	3050	3723	4494	5370	6356
4000	1572	1983	2509	3102	3787	4571	5461	6464
4100	1598	2016	2551	3153	3850	4646	5551	6571
4200	1623	2048	2592	3204	3912	4721	5641	6678
4300	1649	2081	2633	3255	3973	4796	5730	6783
4400	1675	2113	2674	3305	4035	4870	5819	6888
4500	1700	2145	2714	3355	4096	4944	5907	6992
4600	1725	2177	2754	3404	4156	5017	5994	7095
4700	1750	2208	2794	3454	4216	5089	6080	7197
4800	1775	2239	2833	3503	4276	5161	6166	7299
4900	1799	2270	2872	3551	4335	5232	6252	7400
5000	1824	2300	2911	3599	4394	5304	6336	7501
5100	1848	2332	2950	3647	4452	5374	6420	7600
5200	1872	2362	2989	3694	4510	5444	6504	7700
5300	1896	2392	3027	3742	4568	5513	6587	7798
5400	1920	2422	3065	3789	4625	5583	6670	7896
5500	1943	2452	3102	3835	4682	5652	6752	7993

To use the Table, seek the required speed at the top, and the dis-

placement at the side of the page; trace the columns to their intersection, and the number found will be the required power.

The vacuum, in the case of maximum performance of each of the vessels employed in determining the constant c_1 and c_2, was about 26 inches of mercury; and in the construction of the formula it has been assumed that an equal degree of rarefaction will always be secured. If the vacuum be less, in any case, then there will be an additional amount of power required, due to the difference.

As a confirmation of the close approximation to the truth of the assumptions made in the foregoing, it may be stated that, so far as it has been practicable to compare the results of practice (the actual performances of steam vessels,) with those given by the formula, the results have been invariably satisfactory.

It may be stated also, that Morin has found experimentally that, among the forms experimented upon, the form of least resistance was the *sphere:* next in order came the *cylinder*, terminated by *hemispheres*; after this came the cylinder terminated by *cones*. Bosut found that in the case of two models having angles of 12° and 24° at the bow, respectively, the resistances were sensibly equal.

Mr. Rankine, President of the Association of Engineers, of Scotland, and Professor of Mechanics and Civil Engineering, in the University of Glasgow, in his work on Applied Mechanics, p. 599, says:

"From the results of observations of the engine power required to propel vessels of different sizes and figures at different velocities, there is reason to think it probable, that when ships are built of such figures that the water glides round their surfaces without forming surge or large eddies, the principal part, if not the only appreciable part of the resistance is due to the direct friction between the water and the bottom of the ship; and if this opinion should be confirmed by further observation, it will show that the advantage of Mr. Scott Russell's 'wave line' figures, and of any other figures which may be successful in combining speed with economy of power, consists in causing the water to glide past the ship with the least possible agitation and friction; and also, that a certain definite proportion of length to breadth is best, and that not only excessive bluffness, *but excessive sharpness also*, is unfavorable to speed combined with economy of power."

Naval Academy, Newport, R. I., April 11, 1864.

Finely Divided Iron and its Application for the Precipitation of Copper from Solutions and other purposes.

From the Chemical News, No. 205.

Mr. Gustav Bischof, of Skelly, near Swansea, has built a reverberatory furnace at the works of Messrs. Roberts, Dale, and Co., Warrington, for the production of finely divided iron, by heating a mixture of pulverized oxide of iron and carbonaceous matter, avoiding fusion. The powdered iron thus obtained is used for the precipitation of copper from its solutions in the manufacture of aniline instead of iron filings, and for other purposes.

In the manufacture of aniline iron filings may be used as usual, which, having been oxidized, are re-converted into the metallic state as described, thus being employed over and over again.

For the precipitation of copper, Spanish or Irish burnt ores containing a few per cent. of copper are reduced in the above furnace. Both iron and copper in these ores are converted into the metallic state, and being employed for the process of precipitation, the latter mixes with the copper precipitated from solutions. As by these means the whole copper contained in the burnt ores is extracted, the greater value of such copper to the price paid for the ores fully covers the cost of purchase and reduction, even leaving in most cases a considerable surplus.

Trials made with the precipitation of copper from artificial solutions and mine waters by Mr. Bischof have amply proved the powerful action of such iron powder. This process therefore combines the saving of all costs for iron with a greatly facilitated and accelerated precipitation.

Compensated Pendulums for Gravity Escapements. By E. B. DENISON.

From the Lond. Mechanics' Magazine, February, 1864.

SIR:—I have now had time to test by experience a discovery which I made about two years ago of a very remarkable mistake in the hitherto received calculation of the height of the mercury required to compensate a seconds pendulum of the usual construction, and especially those with a cast iron jar.

It was originally given by the late Mr. F. Bailey, P.R.Astr.Soc., in the first volume of that Society's Memoirs; and the calculation there is so long and complicated, that it is not surprising that his statement of the ultimate result has been accepted in faith by other writers. Certainly I should never have thought of wading through it if I had not found that some calculations of my own for a new pendulum to carry 28 lbs. of mercury obstinately refused to conform to Mr. Bailey's within a difference of 2 ins. in the height of the mercury.

The error is nothing less than this:—After taking into account a number of small and comparatively insignificant elements, he altogether forgot the weight of the jar itself, which is not inconsiderable, even if it is a glass one with the usual frame or stirrup; and if it is iron (which, for various reasons, is the best construction), it is never less than one-third of the weight of mercury even in a wide jar, and more in the usual 2 in. jars. And as the rise of the top of the mercury has to compensate not only for the fall of its bottom when the rod expands by heat, but for the fall of the heavy jar also, it is evident that the height of the mercury must be considerably more than if the weight of the jar might be disregarded. Exactly the same mistake was made by Captain Kater in his popular version of Bailey's calculation in Lardner's "Mechanics." In the "Rudimentary Treatise on Clocks," I gave no calculation of my own, but merely stated the generally received result, with a small addition which seemed to be suggested by experience.

For the Journal of the Franklin Institute.

On the Parabolic Construction of Ships.

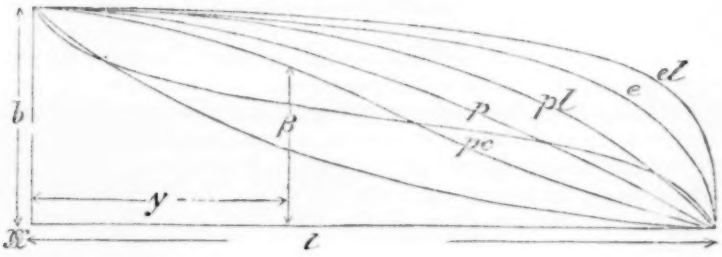
From a Lecture delivered at the Polytechnic College, Philadelphia, Feb. 11, 1864.

By JOHN W. NYSTROM, C. E.

The Parabolic Construction of Ships is now brought to perfection. Its progress has appeared in the *Journal of the Franklin Institute*, and I will here give the conclusive and fundamental formula for the system.

All the lines in a ship can be constructed by one simple formula, namely:

$$\beta = b\left(1 - \frac{y^n}{l^n}\right)^q$$



b = half the breadth.

l = length from X to the stem or stern.

For the frames, d, or the depth from load water-line to the keel, takes the place of l.

β = ordinate for the line.

y = abscissa.

n = exponent.

q = power of the exponent n.

This is the general formula for the Parabolic Construction. Simple as it is, it gives any line or form of a ship that can reasonably be required. It will form a square, rectangle, triangle, circle, ellipse, parabola, hyperbola, cyma; all of any order or combination.

The variety of lines represented by the figure are obtained by altering the power q, while n remains constant; or any variety of lines can be obtained for each value of the exponent n.

It is here found necessary to the development of the subject, to propose or establish new names to such lines as have not heretofore been defined or subjected to an algebraical formula. The degree of development of an art may be correctly matured by the perfection of its vocabulary. As the construction of ships has not heretofore been brought to a perfect system, we have not been able to define the great variety of lines or forms of ships. We can say, a vessel is very sharp, or very full, with more or less rise of floor: but have no language by which to convey correctly, how sharp, how full, or with how

much rise of floor. As an illustration it may be mentioned, that on one occasion I met some shipbuilders, and discussed with them the construction of ships; when one said, "I am constructing a ship that will be so sharp, that you cannot roll a barrel on the lower deck, within fifteen feet of the bow," which made me no wiser. Now, in the language of the Parabolic Construction, to convey the same idea with precision and accuracy, we have only to give the exponent and power, which not only impress the mind clearly with the correct degree of sharpness, but also with the complete form of the vessel.

We have both in Europe and America many curiously constructed vessels, and some of them reported to perform wonderfully, but we have not been able to record their peculiarities; for even the drawing of their lines would fail to convey with correctness what constitutes their novelty or folly.

It is therefore proposed to establish the following technical terms in Naval Architecture:

Any line $p\,l$, in the accompanying figure, located between the parabola p and ellipse e, to be called *paralipse*.

Any line $p\,c$, located under or within the parabola p, to be called *Paracyma*. In architecture, cymas are generally constructed of circle-arcs, but in this case cymas are derived from parabolas.

Any line $e\,l$, extending outside of the ellipse, to be called *Evolipse*.

In modern constructed vessels, those lines are generally distributed as follows:

All water-lines of the displacement are *Paracymas*, with the highest power near the keel, approaching parabolas near the load water-line, which latter may also be a *Paracyma*. The frames are generally *Paralipses* about the middle of the vessel, and terminate in *Parabolas* and *Paracymas*, in the stern and bow. Above the water, the horizontal lines are generally *Parabolas* in the foreship; and in the aftership, *Paralipses*, *Ellipses*, and *Evolipses*.

The power q defines the line as follow:

Parabola p, $\quad \beta = b\left(1 - \frac{y^n}{l^n}\right)^{q=1}$

Ellipse e, $\quad \beta = b\left(1 - \frac{y^n}{l^n}\right)^{q=}$

Circle, $\quad \beta = \mathrm{R}\left(1 - \frac{y^n}{\mathrm{R}^n}\right)^{q=\frac{1}{2}}$

Paracyma $p\,c$, $\quad \beta = b\left(1 - \frac{y^n}{l^n}\right)^{q<1}$

Paralipse $p\,l$, $\quad \beta = b\left(1 - \frac{y^n}{l^n}\right)^{q}$ between 1 and $\frac{1}{2}$.

Evolipse $e\,l$, $\quad \beta = b\left(1 - \frac{y^n}{l^n}\right)^{q<\frac{1}{2}}$.

In a treatise on the Parabolic Construction of Ships, now in progress, tables are calculated for eighteen values of the power q, each

with 48 different exponents n, making 864 different lines; which will cover the most general requirement in practice.

The following is a sample of a part of one table:

TABLE X. PARACYMAS. $q = 1{\cdot}25$.

Exp. n	Ordinates or Cross-sections. 1	2	3	4	5	6	7	Area or Displacement. a $\mathcal{M}$ D	T	Cent. grav. e	$\frac{2}{3}\int\beta^3 dx$ φ
2	·1658	·3559	·5884	·6979	·8273	·9226	·9805	·6239	·0178	·3575	·2785
2·25	·1852	·3960	·5867	7444	·8645	·9450	·9884	·6512	·0186	·3660	·3025
2·5	·2071	·4340	·6302	·7841	·8936	·9610	·9936	·6735	·0193	·3735	·3263
2·75	·2288	·4700	·6695	·8177	·9165	·9724	·9959	·6953	·0199	·3803	·3445
3	·2505	·5041	·7047	·8463	·9344	·9805	·9975	·7164	·0205	·3850	·3615
3·25	·2712	·5362	·7364	·8698	·9486	·9861	·9985	·7353	·0210	·3901	·3774
3·5	·2918	·5664	·7658	8908	·9598	9903	·9991	·7474	·0214	·3954	·3930
3·75	·3121	·5949	·7903	·9097	·9685	·9625	·9994	·7605	·0217	·4006	·4064
4	·3319	·2616	·8130	·9225	·9793	·9951	·9996	·7724	·0221	·4043	·4182
5	·4069	·7128	·8822	·9610	·9908	·9987	·9998	·8099	·0234	·4179	·4564

Either table, exponent, or power, can be employed for either frames, water-lines, or displacement.

$$\left.\begin{array}{l}\text{Area of any water-line } \mathbf{a} \text{ or } a.\\ \text{“ “ cross-section } \mathcal{M} \text{ or } \theta.\\ \text{Cubic content of displacement } \mathrm{D}.\end{array}\right\} = \int \beta\, dy,$$

which integral co-efficient is contained in the column a $\mathcal{M}$ D.

The depth of the centre of gravity of any cross-section, or of the displacement, or the distance from the deadflat $\mathcal{O}$, to the centre of gravity of the area of any water-line, or of the fore or aft part of the displacement, will be

$$e = \int_{\mathbf{a},\ \mathcal{O},\ \text{or D}} \frac{\beta\, y\, dy}{},$$

which integral co-efficient is contained in the column e.

The height of metacentre will be

$$m = \frac{2}{3\mathrm{D}} \int \beta^3\, dy,$$

which integral co-efficient

$$\varphi = \frac{2}{3} \int \beta^3\, dy,$$

is contained in the column φ.

When the power q and exponent n are given, we have,

$$\text{Height of metacentre } m = \frac{l\, b^3\, \varphi}{\mathrm{D}}.$$

$$\text{Momentum of stability } = \mathrm{Q} \sin. v \left(\frac{l b^3 \varphi}{\mathrm{D}} \pm g\right).$$

Q = weight of the vessel, and g = vertical height between the two centres of gravity.

The treatise on the Parabolic Construction, now in progress, will contain fuller explanations, with practical examples and drawings, which, on account of the tables being so complete, requires no algebraical formulas in its application.

On the Numerical Expression of the Destructive energy in the Explosion of Steam Boilers, and on its Comparison with the Destructive Energy of Gunpowder. By GEORGE BIDDELL AIRY, Astronomer Royal.

From the London Mechanics' Magazine, November, 1863.

1. A little consideration of the changes in the state of the water and steam, which occur during the bursting of a steam boiler, will show that very little of the destructive effect of an explosion is due to the steam which is contained in the steam-chamber at the moment of the explosion. The rupture of the boiler is effected by the expansive power common at the moment to the steam and the water, both at a temperature higher than the boiling-point; but as soon as steam escapes, and thereby diminishes the compressive force upon the water, a new issue of steam takes place from the water, reducing its temperature; when this escapes, and further diminishes the compressive force, another issue of steam of lower elastic force from the water takes place, again reducing its temperature; and so on; till at length the temperature of the water is reduced to the atmospheric boiling point, and the pressure of the steam (or rather the excess of steam-pressure over atmospheric pressure) is reduced to 0. It is the enormous quantity of steam, of gradually diminishing power, which is thus produced from water during the course of the explosion, that causes the disastrous effects of the explosion; compared with this quantity, the small volume of gas, which may happen to be in the steam-chamber at the time, is, in boilers of ordinary construction, wholly insignificant, and may be entirely put out of sight in the succeeding investigations.

2. If we compare the course of changes, in bursting, in two boilers, a large one and a small one, we see that the order of changes is the same in both; but that to reduce the temperature of a large body of water by a certain number of degrees, a large volume of steam must escape, whereas to reduce the temperature of a small body of water by the same number of degrees, it will suffice that a smaller volume of steam (smaller in the same proportion as the bulk of water) escape. Thus it will appear that the whole volume of escaping steam at a given pressure, and the whole destructive energy of the steam, are proportional to the bulk of water.

3. For measure of the destructive energy of the steam, we must suppose the simplest and most easily measurable case—namely, that the steam, in expanding, drives a piston along a uniform cylinder. It is necessary to ascertain the value of the pressure F when the steam has expanded so far as to have pushed the piston to the distance x: then the measure of the total energy is $\int F dx$. F, the integral being taken from the point where the piston was in contact with the water

to the point where the excess of pressure of the steam above atmospheric pressure = 0.

In the case of gunpowder fired in a cannon, where the weight of the ball and its velocity on emergence are found by experiment, the energy of the gunpowder as acting on the ball will be thus found:—The pressure at distance y being F′, acting on a ball whose weight is W, and g being the numerical measure of the acceleration produced in one second of time by gravity (g=32·1908 if the unit of measure is the English foot, or =9·8116 if the unit is the French metre), v being the velocity at distance y, and V the whole velocity acquired, then the acceleration is $\frac{F'g}{W}$, and therefore $v\frac{dv}{dy}=\frac{F'g}{W}$, $v^2=\frac{2g}{W}\int dy$. F′, and $V^2=$ total integral $\frac{2g}{W}\int dy$. $F'=\frac{2g}{W}\times$ total energy, whence the total energy $=\frac{W.V^2}{2g}$. And if w be the weight of the gunpowder, the energy of one unit-weight of gunpowder $=\frac{W.V^2}{2g.w}$.

5. Several years ago (before 1849) I had desired in this way to compare the destructive energy of steam from a bursting boiler with that of gunpowder; and I had requested the assistance of my friend, Professor W. H. Miller, of Cambridge (to whose knowledge of the progress of accurate science in every department of physics I have often been indebted), to enable me to give numerical values to the expressions involved. At that epoch, however, the theories and experiments on steam were not sufficiently advanced, and I was compelled to lay aside the inquiry for a time.

6. In the spring of the present year I requested Messrs. Ransomes and Sims, of Ipswich, to furnish me with an experimental result on the quantity of water escaping from a high-pressure boiler in the form of steam when the valve is gradually opened. This experiment was undertaken by George A. Biddell, Esq., Engineering Superintendent of the Orwell Works. The result was that, when the bulk 22 cubic feet of water in a locomotive boiler was raised to the temperature which produced a pressure of 60 lbs. per square inch, and when after raking out the fire the valve was gradually opened without every precaution against priming, the quantity of water which escaped in the form of steam was $2\frac{3}{4}$ cubic feet, or one-eighth of the whole.

7. Possessed of this experimental fact, I again referred to Professor Miller for such theories and citations of experiments as might be required. And by his kind assistance I was enabled to complete the investigation. And here I may state that the whole which follows is Professor Miller's with the exception of the integration of the steam-pressures, the inference from the cannon-experiments, and the comparison of steam and gunpowder.

8. In giving the heads of Professor Miller's theory, I must premise that the temparature are Centigrade, the unit of linear measures is the metre, and the unit of weight is the kilogramme. The formula adopted

as connecting the volume of steam with the volume of water (at maximum density) from which it was generated, is Fairbairn's and Tate's (Phil. Trans. 1860, p. 219). The formula for the number of *calories* required to convert water into saturated steam of temperature T, and the pressure at temperature T, are from Regnault (*Memoirs de l' Institut*, vol. xxi., pp. 748 and 728).

9. The first part of Professor Miller's investigation applies to Mr. Biddell's experiment. The steam-pressure of 60 lbs. per square inch is represented by a column of mercury (at 0 deg.) 3·1028 metres in height. Adding the atmospheric pressure 0·76 metres, the entire elastic force of the steam is represented by a column of mercury 3·8628 metres in height. The corresponding temperature of saturated steam by Regnault's Table, is 152·84 degrees. Now the quantity of water is 22 cubic feet, which at 100 degs. weighs 597·1 kilogs., and the heat requisite to raise the temperature of this water from 0 deg. to 152·84 degs. is $597{\cdot}1 \times 154{\cdot}38$ *calories* (the last number being derived from Regnault's formula $T + 0{\cdot}00002\ T^2 + 0{\cdot}0000003\ T^2$, where T for this instance $= 152{\cdot}84$), or 92,182 *calories*. When all the steam has been blown off, the 597·1 kilogs. of water are separated into x kilogs. of steam at 100 degs., and $(597{\cdot}1 - x)$ kilogs. of water at 100 degs. [This applies strictly when the steam has blown into a cylinder and has driven a piston, because then there may be such intercommunication of temperature between the portions of steam as will ensure that the final state of the steam is that of saturated steam at 100 degs.; it is probably true or very approximate when the steam has blown out at different temperatures and has been lost in the atmosphere.] To heat $(597{\cdot}1 - x)$ kilogs. of water from 0 deg. to 100 degs. requires $(597{\cdot}1 - x) \times 100{\cdot}5$ *calories;* and to convert x kilogs. of water at 0 deg. into steam of 100 degs. requires $(606{\cdot}5 \times 0{\cdot}305 \times 100) \times x$ *calories* (by a formula of Regnault's). Supposing, then, that the amount of heat as measured by the number of *calories* is not altered by the blowing out from the boiler,

$$92{,}182 = (597{\cdot}1 - x) \times 100{\cdot}5 + 637 \times x,$$

whence x, the weight blown out as steam, $= 59{\cdot}8$. This, however, is equivalent to only 2·2 cubic feet of water, instead of 2·75, the quantity which Mr. Biddell found to have passed away in steam.

10. Professor Miller supposes the difference to be caused principally by the heat of the mass of iron which surrounds the water; any burning fuel which may have been left in the fire-box would add slightly to its effects. It appears best, therefore, to assume the experimental fact, and to infer from it what quantity of heated water we ought to add (in investigation) to the quantity of water really present in the boiler, in order to produce correctly the amount of water which in the experiment was blown out as steam. Now 2·75 cubic feet of water at 100 degs. weighs 74·638 kilogs. Let y represent the number of kilogs. in the bulk of water which may be considered equivalent to the compound consisting of 22 cubic feet of water, the unknown weight of iron, and the unknown quantity of fuel. To heat y kilogs. of water from 0 deg. to 152·84 degs. requires $145{\cdot}38 \times y$ *calories;* and this is the

amount of heat in the complex equivalent before blowing off. To heat $(y-74{\cdot}638)$ kilogs. of water from 0 deg. to 100 degs. requires $(y-74{\cdot}638)\times 100{\cdot}5$ *calories;* and to convert 74·638 kilogs. of water at 0 deg. into steam at 100 degs. requires $74{\cdot}638\times 637$ *calories;* and the aggregate of this with the last, or $(y-74{\cdot}638)\times 100{\cdot}5+74{\cdot}638\times 637$, represents the number of *calories* in the complex equivalent after the blowing off. Making this equal to the number before blowing off. $154{\cdot}38\times=(y-74{\cdot}638)\times 100{\cdot}5+74{\cdot}638\times 637$, whence $y=743{\cdot}2$.

Comparing this with the weight of the 22 cubic feet of water alone, or 597·1 kilogs., it appears that the heated materials extraneous to the water produce the effect of 146·1 kilogs. of water.

11. Assuming then that there are really 743·2 kilogs. of heated water, the investigation of the destructive energy proceeds thus:—To heat 743·2 kilogs. from 0 deg. to 152·84 degs. requires $743{\cdot}2\times 154{\cdot}38$ *calories* = 114,740 *calories;* and this is the quantity of heat for which we must account in every stage of the expansion, when the steam is allowed to blow into a cylinder and drive a piston before it. Now at any instant let w be the number of kilogs. of water converted into saturated steam; T the common temperature of water and steam; Q_T the number of *calories* required to heat 1 kilog. of water from 0 degree to T; A_T the number of *calories* required to convert 1 kilog. of water at 0 degree into steam at T; P_T the pressure of saturated steam at T in milimetres of mercury at 0 degree; K_T the same pressure in kilogrammes per square decimetre (all which are given for numerical values of T by Regnault); V_T the ratio of the volume of saturated steam under pressure, P_T to the volume of the water at 0 deg. from which that steam is derived (which is given by Fairbairn's formula). Then, forming the expressions for the number of kilogs. of water and steam respectively, and multiplying each by its corresponding number of *calories,* and equating the aggregate to the original number of *calories,*

$$114{,}740=(743{\cdot}2-w)\times Q_T+w\times A_T.$$

From this formula, with any assigned numerical value of T, w (the number of kilogrammes of water converted into steam) is found in numbers. And V_T the ratio of the volume of the steam generated to that of the water from which it is generated, is taken in numbers from Fairbairn's formula. And a kilogramme of water occupies one cubic decimetre of volume. Therefore the volume of steam, in cubic decimetres, is $w\times V_T$, of which w are left in the boiler to occupy the place of the expanded water; add the volume of steam expelled from the boiler is $w\times(V_T-1)$ in cubic decimetres, or $\frac{w}{1000}\times(V_T-1)$ in cubic metres.

12. Suppose, now, that the steam in escaping enters a cylinder whose section is 1 square metre, driving a piston before it. Let z be the distance to which the piston has traveled (the unit being the metre). Then $z=\frac{w}{1000}\times(V_T-1)$. And the pressure of the steam on the piston (the unit being the kilogramme) is $100\times K_T$. Therefore the two ele-

ments, the distance of the piston and the pressure upon it, can be calculated numerically for any number of numerical values of T. To find the effective pressure, the pressure first found must be diminished by the atmospheric pressure, or by the pressure of steam at 100 degrees, and it thus becomes $100\times(K_T - K_{100})$. The limit of the length of the cylinder will be determined by finding where the steam pressure = atmospheric pressure. By Fairbairn's formula, 74·638 kilogrammes of saturated steam at 100 degs. (the quantity which escaped in Mr. Biddell's experiment) occupy 122·28 cubic metres; of this, 0 0746 cubic metre remains in the boiler, taking the place of the water from which it was produced; the whole volume expelled is therefore 122·21 cubic metres, and the limiting length of the cylinder is 122·21 linear metres.

13. By these methods Professor Miller calculated the following corresponding values of z, the distance to which the piston has travelled (the unit being the metre), and F the effective pressure on the piston (the unit being the kilogramme). The degrees of temperature are also given, as they are the elements from which z and F are computed; but they are not in any way used in the subsequent calculations.

T. Degrees of Centigrade.	z. Metres.	F. Kilogrammes.
152·84	0	42,185
150	1·621	38,356
145	4·743	32,162
140	9·345	26,615
135	14·740	21,668
130	21·541	17,271
125	30·136	13,377
120	40·976	9,943
115	54·708	6,926
110	72·186	4,288
105	94·325	1,991
100	122·21	0

14. The effective energy of the expanding steam, as shown (for instance) by the momentum communicated to a material piston, will be represented by the integral $\int dz \cdot F$. As the symbolical form of the function F is not known, it is necessary to perform the integration by quadrature. For this purpose I laid down the twelve data of this Table graphically (taking z as the abscissa, and F as the ordinate), and drew a curve by hand through the points so defined. Then I measured the ordinate for each of the values of z; 0, 1, 2, 3, &c. And I integeated them by the formula $\frac{1}{2}$ (first ordinate + last ordinate) + sum of intermediate ordinates — 1·12th sum of second differences; where it is seen that sum of second differences is sensibly equal to — first of first differences. Thus I found the integral

1,131,400

which is the true measure of the energy of the 22 cubic feet of water at the temperature which produces the pressure 60 lbs. to the square inch, in a hot iron boiler, the units of the energy being the metre and the kilogramme.

15. If this be diminished in the ratio of 743·2 kilogrammes (the

fictitious weight of water on which Professor Miller's calculations are made) to 597·1 kilogrammes (the real weight of water), then we shall have for the measure of the energy of the 22 cubic feet of water at the same temperature unassisted by the hot iron of the boiler,

909,000;

and if we divide the two numbers by 22, we have for the energy of one cubic foot of water a temperature producing a pressure of 60 lbs. to the square inch.

As surrounded by hot iron, 51,400. (This is the practical value.)
Without influence from surrounding iron, 41,300. (This is the philosophical value.)

16. I now proceed with the evaluation of the energy of gunpowder. The formula applicable to cannon experiments is given in Art. 4. Professor Miller referred me to a series of experiments by General Didion, in his *Traite de Balistique*, p. 485. These experiments were made with cannon of four different bores, and with eighteen different charges of powder, in each cannon. The first thing to be done was, to find by trial for each cannon, by means of the formula $\frac{W \cdot V_2}{2g \cdot w}$ (which for a single cannon may be reduced to $\frac{V^2}{w}$), what was the charge of powder in which the momentum produced bore the greatest proportion to the weight of the powder. It was found to be the following:—

With ball of 12 kilogs.,	1·500 kilogs. of powder.	
" 8·07 "	1·250	"
" 6·08 "	0·875	"
" 4·05 "	0·625	"

Then adopting these four for comparison among themselves, by the formula $\frac{W \cdot V^2}{w}$, it was found that the cannon in which the powder was most efficient was that with a ball of 6·08 kilogrammes. Here it may be desirable to state that the bore was 0·1213 metre, the diameter of the ball 0·1182 metre, the length of the bore 2·815 metres; and, with the charge of powder 0·875 kilogramme, the velocity of the issuing ball was 400 metres per second. Applying the formula $\frac{W \times V_2}{19{\cdot}623 \times w}$, the energy of 1 kilogramme of gunpowder (as fired in a cannon) is found to be 56,656,

and that of an English pound of gunpowder.

25,700,

the units being in all cases the metre and the kilogramme.

17. Comparing this with the numbers found in Art. 14, we have,

The destructive energy of 1 cubic foot of water at the temperature which produces the pressure 60 lbs. to the square inch, surrounded by hot iron, is precisely equal to the destructive energy of 2 lbs. of gunpowder as fired in a cannon.

18. The destructive energy of the hot water, however, abstracting the effect of the surrounding hot iron, is considerably less than the number used in this comparison; and the destructive energy of the gunpowder, abstracting the effects of windage, cold iron, and short barrel, is considerably greater than the number used for it. Without pretending to form an accurate estimate of these effects, I think that their combination, with that affecting the energy of the water, may have diminished the apparent proportion of the energy of gunpowder by one-half. In that case,

The destructive energy of 1 cubic foot of water at the temperature which produces the pressure of 60 lbs. to the square inch, is equal to that of 1 lb. of gunpowder.

On the Duty of the Cornish Pumping Engines. By Mr. W. Morshead, Jr.

From the London Artizan, Dec., 1863.

It appeared from a tabular statement prepared by the proprietor of "Lean's Engine Reporter," for the years 1841 to 1860 inclusive, that the average duty of these engines had fallen off from 68 millions in 1844 to 52 millions in 1860, or 25 per cent.; also that less interest was now felt in the performance of these engines, as while fifty were reported in 1841, only fifteen were reported in 1858 and twenty-five in 1860. Although the nominal, or reported duty showed this marked diminution, it was not asserted that there had been an actual falling off to the extent thus indicated;—for the duty paper did not take into account the quality of the coal, which was certainly inferior to that used twenty years ago; besides which the present practice of sinking the engine shaft, for the whole, or part of its depth, in an inclined direction upon the course of the lode, must have tended to increase the friction of the pit work, and the mines were also deeper than formerly. Nor was expansion of steam adopted to so great an extent now as it was some years ago; it was then carried further than was compatible with safety, as was evinced by the repeated breakages of the main rod, the piston rod, and the other principle parts of the engine. But after allowing for all these legitimate causes of the falling off of duty, it was thought that the average duty of the county was still at least ten millions below what it should be.

The Author next examined the causes of this decline, and then discussed the means by which it might be remedied. The primary cause he believed to be, the indifference of the mine proprietors to the performance of the engines. So many accidents attended the use of high steam, cut off at an early part of the stroke that economy of fuel came to be regarded as synonymous with repeated breakages; but it was quite possible to raise the duty considerably above the present average, without resorting to an undue rate of expansion. This might be accomplished by a more perfect and extended system of reporting the engines, and by a new form of duty paper, embracing the following additional items:—First, that the load upon the piston should be

taken from an indicator diagram, and from the load thus ascertained the duty should be computed, the difference between the load upon the piston and the weight of water actually lifted, that was the loss by the friction of the pitwork, &c., being placed in a separate column. Secondly, that the part of the stroke at which the steam was cut off, as well as the vacuum obtained, should be stated opposite each engine. Thirdly, that a notice of the quality of the coal used, as far as it could be ascertained, should be added. And lastly, that the engines should be separated into two classes, those which might reasonably be expected to give a good duty, and those which, from the time they had been at work, their small size, or other causes, could not fairly compete with the former. By taking the load upon the piston from an indicator diagram, a fair estimate of the work actually done by the engine could be formed, while by placing the difference between the load upon the piston and the weight of water actually lifted in a separate column, encouragement was offered for improvement in the construction and fixing of the pitwork.

At present only about one-tenth of the engines at work in Devon and Cornwall appeared in the monthly reports. If mine proprietors would co-operate in supporting a good form of duty paper, there was little doubt but that there would be a rapid and marked improvement in the duty of the Cornish engines.

Photographing Natural Colors.

From the Practical Mechanic's Journal, December, 1863.

It has often been asserted, but never yet substantiated, that the photographic process was capable, under certain mysterious processes, of reproducing the colors of the spectrum, and not merely the gradations of black to which we are accustomed. A few years ago, an American, a Mr. Hunt, startled the scientific world—at least that part of the world which knew anything about photography—by insisting that he could produce any color in the photographic image. Practically speaking, this announcement came to nothing. Now, we find in Milan, something at least has been recently done for the furtherance of the idea. Suppose it be required to color the photograph of a man in a black coat, whose hair and beard are fair, and whose figure is projected on a white foreground, slightly shaded off, the process of the inventors is as follows:—The photograph, taken by daylight, lies in a basin full of water: it is dark, and the subsequent operations are performed by candle-light. Two solutions are at hand, one A, consisting of one gramme of chloride of gold and ten of acetate of soda, dissolved in 1000 grammes of water; the other, B, consisting of 20 grammes of hyposulphite of soda dissolved in 100 grammes of water. There are besides two more basins with water, and a quire of blotting paper. The photograph is taken out of the water and put between the leaves of blotting paper; it is then laid flat on a pane of glass, and the whole surface, except the face and hands, receives with a water-color brush a coating of solution B. By this means the parts subjected to the action of the gold soon change their tints into black. The photograph

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is then put into clean water again, and left there for a few minutes, during which the operator prepares a second photograph if required. The former one being taken out, is put into solution B, where it stays for a few minutes, and is then washed and rinsed as usual. Now, as the time of immersion will influence the depth of color, by successive immersions an orange-colored cravat will be obtained in one minute, a coffee-colored great-coat in five, violet-colored trousers in ten, and a black coat in thirty minutes, while the hyposulphite of soda, or solution B, gives color to the flesh and hair. Hence certain colors, though not quite the natural ones, may be obtained, which is a decided step in advance of what had been previously achieved.

Theory of Magnetic Storms.

From the London Athenæum, Jan., 1864.

In a paper read at the last meeting of the Royal Society, the Astronomer Royal propounds a theory to account for the phenomena known as magnetic storms. The behavior of water under the influence of different currents and various obstacles, as, for example, among islands, has been often observed and described; and this may be taken as one illustration. Another is found in the behavior of air during disturbances of the atmosphere. These phenomena, in Mr. Airy's opinion, represent the movements of a magnetic ether which he supposes to overspread the whole surface of the earth as an impalpable fluid envelope several feet in thickness. If we then conceive this magnetic ether "to be subject to occasional currents produced by some action or cessation of action of the sun, which currents are liable to interruptions or perversions of the same kind as those in air and water," we have a theory by which the disturbances that occur in the observed phenomena of terrestrial magnetism may be explained. This theory, emanating from so important an authority, will, no doubt, attract attention in many quarters. Mr. Airy believes that the questions involved might be decided by a series of observations made "at five or six observatories spread over a space less than the Continent of Europe." For accuracy of results he would prefer self-registering apparatus properly constructed.

"The report of my communication to the Royal Society, 'On Magnetic Storms,' contained in the *Athenæum* of the 2d of January (p. 23, col. 3), is perfectly correct except in the mention of the supposed depth of the magnetic ether, which is stated in the report of the *Athenæum* as perhaps several feet in thickness. In my communication to the Royal Society I made no allusion to the probable measure of the magnetic ether's depth; but I may now state, as my idea, that the supposed ether extends much higher, perhaps as high as mountain-tops, possibly as high as the atmosphere; and somewhat lower, probably permeating the external crust of the earth. These suppositions do not depart from the character of 'surface-current,' a term which I used in the discussion at the Royal Society's meeting.

"Yours, &c. G. B. AIRY."

Royal Observatory, Greenwich, Jan. 4, 1864.

For the Journal of the Franklin Institute.

The Proposed Dictionary of Mechanical Fallacies.

As this has been thought rather anomalous and outré, a few more thoughts on it may not be deemed out of place. The proposition is not so preposterous as it may seem, nor is it so at all. The principle is universally recognised. In all things we need to be shown the evil and the good. To appreciate the one we *must* know something of the other. While ignorant of follies how can we become wise? Intelligence is a ceaseless struggle with error in social, civil, political, philosophical, mechanical, and every other department of life. In none is truth obvious at first; so far from lying on the surface to be stumbled on, it has to be sought for, dug for, and that earnestly and perseveringly. There are what may be called ordinary deductions, extrinsic rather than intrinsic, but truth is the inbeing, the essence of excellence in every thing. In the arts it is the shortest way to an object or end; it goes to it in straight lines, while error stumbles zigzag around it. It is swiftness, strength, elegance, or whatever the attribute may be. In forms and proportions it is beauty; in the absence of meretricious accessories and ornaments, it is taste. The simpler a machine is, the truer it is, for the expression of truth is simplicity. Then mechanical like moral verities only are enduring.

Another point about truth is, that people never speak of it as something to be estimated, as are lands, money, and goods, *by the quantity*. The idea seems to prevail that where it is, error cannot be, that the two can no more mingle than fire and water; whereas, truth is in reality alloyed in every conceivable proportion. Here it is largely manifest; there, like a grain of silver in a pig of lead, its presence is not suspected. It is therefore something of which a little will not suffice in physics any more than in morals. It may exist in a mechanical process or device, and be neutralized by association with fallacies; of which every poor machine is a proof. Results can only improve as it predominates; and herein lies the difference between the works of nature and those of man. In the former all is truth and consequently harmony and beauty, while discords and deformities characterize the latter. The best of these are to be improved by adding to the amount of truth in them.

As a class, to none is the caution, "Beware of Fallacies," more necessary than to inventors. Of all men they ought to know that truth is only to be reached through conflicts with error—through that which steals on them in flattering guise and captivates them with plausible counterfeits. It may seem strange that so many keen and shrewd inquirers fall into mechanical sophistries, and what is worse, fall in love with them, but the illusions are too seductive to be resisted. The fact is as true in physics as in morals,

> "When fiction rises pleasing to the eye,
> Men will believe because they love the lie."

Witness those who yet befool themselves with Perpetual-Motions, the grossest of mechanical falsehoods.

In ordinary as in the highest affairs, directions abound to prevent people from going astray. We have guide-posts for travelers on common roads, and Government spends millions to make seamen acquainted with shoals and other dangers of navigation by day, and on beacons and lighthouses, to direct them into safe harbors at night. For the benefit of merchants there are in most cities, "Commercial Agencies," institutions whose only capital consists of dictionaries of solvent and insolvent traders. And have we not lists revised weekly of counterfeit bank bills, and spurious coin? Naturalists are as earnest in discovering and making known noxious, as innocuous animals and plants, while chemists keep adding to the list of vegetable and mineral poisons. Such are examples of measures adopted to make evils known that they may be avoided, and which are increased and extended as occasions call for them.

Why then, it may be asked, has nothing been done for those who are devoted to the progress of the arts to warn them of paths that lead them astray? Why should they be left without compass or chart to find their way over the ocean of speculation? Simply because the necessity for such help was not perceived or not sufficiently felt. If not yet palpable, it cannot, we should suppose, be much longer ignored. There is no valid objection to its removal, for whatever may be thought of the exposure of moral offences, the making public transgressions of mechanical laws can do no harm, but much good. A hand-book of errors is a guide book to truths. It would open the eyes and diminish the number of offenders.

As progress depends upon original thinkers, and especially those whose labors comprise the magnificent and minutest exemplifications of applied science, a work calculated to save them from loss of time, and much useless expenditure of thought and labor, must be of permanent and universal interest. But as intimated in a previous notice, its value would not be confined to them. The reform it would work out in the Patent Office should not be overlooked, in abridging its labors, putting an end in a great measure to inadmissible claims, to disappointments and angry feelings attending rejected applications, to appeals of members of Congress in behalf of their constituents, to contingent fees of agents, and to other improper influences and interferences. Added to which it would raise the value of every legitimate claim, diminish the number of lawsuits, and give to the office an honorable reputation as an Institution of Science. Its reports would cease to record monopolies for ancient contrivances and modern abortions.

The running of anything like a parallel between the laws or principiples of ethics and physics may be unusual, but is not improper, since they are intimately and inseparably allied. Emanations of the divine mind, they are equally divine. The same in their origin, essence, and purpose, it is they that impress the Deity on the material and the immaterial; hence the visible creation is an exhaustless exposition of the principles on which the arts must for ever rest; and nothing is more certain, whatever may be the case with transmundane intelligences, than that our species can only advance in civilization and happiness, as

it advances in the knowledge and application of them. With us, moral truths begin with, and keep pace with, the physical. As a savage, man has no morals; they are incomprehensible to him. "Even the Arab robs the traveler with as little compunction as a bald eagle wrongs a fish-hawk, while the Fejiian eats a missionary as unconscious of guilt as a tiger feasting on an antelope, or a lion making a meal of a Bojesman." Material are moral forces. The hut and the hearth, the spindle and loom; the plough, forge and lathe; steamships, railroads, and printing presses, are products of mental and contributions to moral power. I mention these things because, to my mind, they are prophetic of the exaltation and influence of mechanical science to a degree that has probably not yet been suspected; and that the higher it rises the closer will be found its affinity with moral science. This *must* be so, since Truth in its infinitely varied forms and relations, like its Author, is ONE.

There are, and perhaps always will be, those who suppose the climax of mundane felicity was reached long ago. Panegyrists of former times, they think the world grows worse as it grows older. Looking back to a legendary age of gold, one of imaginary innocence and happiness, they mourn that it has passed away. An opposite and healthier sentiment now prevails, viz: that the elements of civilization were never so numerous and so efficiently active; that great as has been the modern increase and diffusion of knowledge, and wonderful the achievements in science and the arts, all are but preliminary to others still greater. This is a corollary of the prime doctrine of progress; that nothing in creation remains stationary or is designed to retrograde. While we realize all that we are prepared for, we transmit it with an increased volume and impetus to our successors, whose mission it will be to forward it, in like manner, to theirs; every age being a debtor to the preceding one, and a creditor to that which follows it. Is it asked, how long can this continue—Can additions to human knowledge be perpetual? Yes: at all events, as long as the forms, motions, and properties of matter here are not worn out. But may not the intellect become unequal to the successive development of new principles and management of new forces? No: It is indisputable that the more it is expanded, the more readily it apprehends and lays hold of new truths; and it is in a high degree probable that these become more lucid and simple as they become more comprehensive and sublime. E.

New York, February 20, 1864.

On the Influence of Megass on Animal Decomposition. By HENRY G. DALTON, M.D., Georgetown, Demerara.

From the Journ. Soc. of Arts, No. 580.

I have noticed some particulars attending animal decomposition when subjected to the influence of megass, or the dried stem of the sugar cane after the saccharine juice has been crushed out by machinery. But before entering upon the circumstances which first led me to consider this subject, it may be as well to state that the sugar cane,

which is sufficiently known to render any description of it quite unnecessary, after having been crushed by massive iron rollers worked by steam power, is stacked under large sheds open at the sides, but protected by slated or wooden roofs, where it is kept until sufficiently dried to be used as fuel for the boilers. When first stacked, it is known as green megass, being then in a more or less fresh state, and emits a powerful sweetish odor, and is evidently the resort of millions of small gnats and other minute insects, for towards morning and evening the Megass logies, as they are called, are surrounded by swarms of swallows and other birds which evidently come here to obtain a bountiful repast.

But in this raw or green state there exists another striking and peculiar condition; there is an enormous amount of heat developed, causing the hands if thrust in to be quickly withdrawn, and a certain amount of steam or vapor is noticed. Both in this state and when more completely dessicated, megass is very combustible, and fires, spontaneous or accidental, frequently occur in these logies. It has often occurred to me to think that certain gases are generated during these changes, which probably tend to explain some of the peculiar facts about to be noticed.

On the 31st January, 1863, I was summened to attend a coroner's inquest, and examine a dead body found in one of the megass logies on an estate on the west bank of the river Demerara. On approaching the spot where the corpse was stated to be, there was no fœtid odor as usual to indicate its presence, and on climbing up the dried megass, I saw the corpse of a human being partially embedded in megass, but without odor, and in a completely mummified condition. There was a fold of cloth twisted round the neck, and this joined another fold attached to a beam close by, leading one to suppose that death had occurred from strangulation. The body was completely dessicated, shrivelled and brittle, so much so that on tryiug to draw the corpse towards me by means of a pick for the purpose of examination, I was surprised to find the head separate completely from the trunk. On more closely examining the body the following facts were noticed:

There was not the usual odor of a body long since lifeless, and exposed to the action of the air in a tropical climate.

The muscles, soft parts, and internal organs were shrivelled, dry, and parchment-like in character.

The sex (male) barely distinguishable; the lower limbs were bent at an obtuse angle, and the skin and muscles clung round the bones like paper stretched over boards; the skull and face were denuded of all muscular and ligamentous traces, so that the disarticulation of the lower maxilla and cervical vertebræ was complete.

By the shaven crown and tuft of long hair, I recognised the body to be Chinese, and the only identity as to name, &c., arose from the peculiarities of the teeth, and from the absence of certain of them, which enabled some of the other Chinese immigrants to conclude that the deceased was one of their countrymen, who had been missing from the estates for several weeks.

This body, then, had been lying loosely covered with megass in the place where it was found for probably several weeks, during which time, although laborers were constantly in the neighborhood, it had attracted no notice by any noxious effluvia, nor was it even spied out or scented by the carrion vultures (*Cathartes Jota*), who seldom fail to detect dead carcases of any description, however obscured in the mud or the tangled bush of this colony.

Struck with so singular an appearance and condition, and with the remarkable absence of noxious smell, it seemed to me to be the result of some influence exercised by the megass on which the body had fallen or been thrown, and with a view to elucidate this, I instituted the following experiments:

1st. On the 1st April, 1863, I buried a dead goat loosely in megass, and visited the spot on the 3d, but could only detect a faint odor of decomposition, quite unlike the intolerable stench which is so common here in dead bodies exposed to the sun and air. On repeating my visits a few days afterwards, I found that the dead goat had disappeared, and on inquiry, found it had been stolen by some Chinese, who had speedily devoured it, so that it could not have been very offensive, for although our celestial immigrants are incorrigible thieves, and not very particular as to the quality and condition of their food, they would hardly have appropriated this first subject of my experiment had it not been more or less preserved by the agency of megass.

On the 27th of the same month I buried another dead goat in a similar manner, but somewhat more securely out of reach of the Chinese, and disinterred it about 30 days after, or on the 27th May. During that time I had repeatedly visited the neighborhood, accompanied by others, and not one of us could detect the slightest offensive odor. On examining the body, which by-the-bye was completely disintegrated, there was no other trace of noxious effluvia than is peculiar to the dried skin of an animal. The head was denuded of all muscular and ligamentous attachments. The orbits were empty, and the bones forming it perfectly clean, likewise the nasal structure, palate, and jaw-bones. Several disarticulated vertebræ were found loose and totally void of muscles and ligaments, likewise the ribs and other parts of the body, as far as they could be gathered; the outer casing of one horn was completely detached from its osseous support, and the rest of the carcase was in a fragmentary state, dry and scentless. There were no ants or other insects visible to account for this complete disintegration, but possibly whilst the noxious odor of decomposition was neutralized by the heat or gases developed by the megass, the work of destruction of the soft parts might have been carried on during the month of interment by ants and other insects, although no trace of them was visible at the time of my inspection.

Of the many practical advantages to which the discovery of the disinfecting properties of megass, if confirmed by further experience, might apply, I do not think I need offer any remarks at present, or until the subject has been more fully examined. I may mention, however, that an occasion lately presented itself by which I was enabled

to test its value, and to prove its efficacy as a very useful agent in a sanitary point of view.

Shortly after my experiments on the properties of the megass, I was much concerned at the outbreak of a number of cases of sloughing ulcers on the feet and legs of the East Indian immigrants (Coolies and Chinese), in one of the Estates' Hospitals under my medical charge, and my anxiety was still further increased on the appearance of hospital gangrene among some of the worst cases. Not only in the wards where the unfortunate patients slept, but throughout the whole hospital, the effluvium was most offensive and disagreeable. After making use of several medical disinfectants in vain, I determined to make a trial of the megass.

I desired several large baskets to be filled with it, and placed them in the corners of the wards by the doorways, and in the gallery to windward of the rooms, and on my next visit was agreeably surprised to find the obnoxious odors greatly lessened. I continued its use, and in a short time (two or three days) the change for the better was very remarkable. Except in the immediate neighborhood of the worst cases, there was no unpleasant odor, and even then the disagreeable smell was greatly modified.

Unfortunately there was no corresponding improvement in the character of the sores decidedly attacked by gangrene, but the general improvement in the hospital was manifest, for not only was the unhealthy effluvium neutralized by the megass vapor, but the peculiar, pleasant, and sweet flavor of the cane, was disseminated through the whole hospital, rendering its atmosphere fresh and agreeable, so much so, that in spite of the disappearance of the gangrene, and the existence merely of ulcers of an ordinary kind, its use and benefit are still appreciated by the nurses and patients, who are assiduous in constantly keeping up a fresh supply.

In submitting these few remarks on a subject altogether new, I think I may venture to state that in green megass we possess an agent competent materially, if not entirely, to neutralize noxious gases, and thus by arresting or destroying the offensive odors of animal decomposition, and the foul air of hospitals, to prove of eminent service and benefit in a tropical country, where these unpleasant and injurious conditions are too apt to prevail.

On the part that Titanium plays in Pig Iron and in Steel.

From the London Practical Mechanic's Journal, December, 1863.

A valuable paper was read at the Newcastle meeting of the British Association by Mr. Edward Riley, F.C.S., "On the occurrence of Titanium in Pig Iron, and on the use of Titaniferous Minerals in the manufacture of Iron and Steel." The coppery red cubic crystals examined long ago by Wollaston, and procured from the hearths of the South Wales Blast furnaces, were considered by him as metallic Titanium, and passed as such for years.

Wohler subsequently proved that they were a mixture of azoturet

and cyanide of titanium, and contained 18 per cent. of nitrogen and 4 per cent. of carbon.

It is quite clear, however, that the history of this body is not yet complete, for we had long since ourselves remarked what Mr. Riley mentions, that in a mass of these crystals, as taken from the hearth, some are attacked by nitric acid and converted into titanic acid, while others are perfectly insoluble in that menstruum.

Mr. R. Mushet, under whose hand metallurgic patents grow month by month like mushrooms, has taken abundant care to advertise the world of the existence and value of his "Titanium Steel," and other similar metallurgic marvels. The proverbial "Dowsterswivel" reputation that mercantile metallurgy of the thaumaturgic and recondite sort has but too justly acquired, clung with many pretty well-informed persons to the whole titanic brood—when they called to mind that no one had been able chemically to detect any titanium in even Mr. Mushet's own titanium steel; that Mr. Riley in confirmation of this says, he was never able to find it in more than uncertain traces, and that Dr. Percy, and St. Claire De Ville, who had paid special attention to the subject, denied that iron was capable of alloy with titanium at all.

The matter has been tested latterly upon a tolerably large scale as regards crude pig iron at Middlesboro', where importation was made of some cargoes of Norwegian rutile, or natural titanic acid, and a very remarkable massive black titanate of iron; and those were employed along with the Cleveland ores. The following is the composition of the Norway ore in two samples by Mr. Betley's analyses :—

	No. 1.	No. 2.
Magnetic Oxide Iron, . .	46·14	54·72
Titanic Acid, . . .	36·88	40·80
Silica, ...	13·32	1·58
Magnesia, . . .	2·07	2·13
Lime, ...	0·78	0·66
Iron Pyrites ($Fe S_2$), . .	1·05	0·00
	100·24	98·99
Yield of Metallic Iron, . .	33·39	39·62

Neither contained phosphorus.

Rutile can be imported into Middlesboro' at £10 per ton, and these titanates at about thirty shillings per ton.

From Iceland, Sicily, the North-West of Neapolitan Italy, and other volcanic regions, if it were of any use, titanate of iron could be had for the mere cost of collection and freight home.

Iron made with red hæmatite and a mixture of bog iron ore from Ireland, with 7½ per cent. of these Norwegian minerals, did in some instances yield to Mr. Riley on analysis as much as 3·51 per cent. of titanic acid, but they contained *none* unless the Irish bog ore had formed part of the mixture.

More recently trials have been made with mixtures of Cornish ores, Irish bog ore, and red hæmatite, and the pig was found to contain *some* titanium.

The Cornish ores Mr. Betley found, were—

	No. 1.	No. 3.
Silica,	23·38	27·18
Peroxide Iron,	41·96	47·82
Peroxide Manganese,	25·77	16·35

with a little phosphoric acid.

From these the iron obtained had the following composition:—The bog ore employed contained 7 to 9 per cent. of manganese:—

Pig Iron.	No. 1.	No. 2.	No. 3.
Graphite,	3·120	3·010	2·615
Carbon combined,	0·310	1·020	0·674
Silicon,	2·590	2·550	3·325
Iron,	89·900	86·880	84·256
Manganese,	5·850	6·370	8·007
Nickel and Cobalt,	0·060	0·110	. .
Copper with Antimony,	0·060	0·045	0·064
Phosphorus,	0·147	0·154	0·201
Sulphur,	0·026	0·026	0·017
Titanium,	0·790	1·150	0·629
	100·853	101·315	100·268

We have here, therefore, something above 1½ per cent. of titanium, but the manganese is present in form nearly 6 to above 8 per cent. also.

Mr. Riley remains in doubt whether the titanium, even here, is alloyed or only minutely diffused, in an amorphous state, through the pig iron.

The repetition of analyses of M. Mushet's steel, failed in his hands to give any evidence of the presence of titanium. He remarks that the use of titanic ores involves that of a considerable addition of an easily fusible silicate, as a flux in the blast furnace, for otherwise the reduction is difficult, and the cinder tough and ropy, and hard to separate from the metal. Mr. Riley is prepared to admit, however, that the presence of titanium in iron ores does not appear to impart a steely nature to the iron made; and, in conclusion, so far, on a subject which he considers still demanding further research, he expresses his opinion that probably the part of titanium in iron is limited to its acting as a carrier of cyanogen to the iron with which it is mixed or combined, in the process of its conversion into steel, which seems to be supported by the ascertained affinity of titanium for nitrogen and carbon. To us it appears extremely doubtful still, that it exercises any influence whatever, for good or for ill, and that the large per centage of manganese present almost wherever titanium has been detected, has played the really important part in facilitating or improving the production of the steel.

The power of manganese in this respect is ascertained, although no doubt, as yet, much remains to be learnt as to its mode of action,

and which will probably only be cleared up when the action of nitrogen in the production of steel shall have been better studied and understood.

In concluding this *resumé* of Mr. Riley's interesting researches, we may remark that there are in the South of Ireland enormous deposits (not bog ores) of poor ores of manganese, that may be viewed as very pure and highly manganesiferous iron ores.

These we should deem far more worthy of metallurgic trials upon the great scale, for the production of British pig of the *spiegeleisen* class, fitted for the Bessemer and other processes of steel-making, than probably any other in Great Britain.—Ed.

On a Curious Instance of Electrolytic Action. By F. A. Abel, F.R.S.

From the Journal of the Chemical Society, July, 1863.

The inspection of a number of the lead-coated projectiles employed with the Armstrong guns, has recently brought to light some curious and quite unexpected instances of the establishment of voltaic action within the coatings of certain of these projectiles, and in positions where the existence of an exciting cause was not at all anticipated.

It has been customary to attach the coating of soft-metal (which is an alloy of lead with a small proportion of tin or antimony) to the body of the cast iron projectiles, by two different methods. The one consists in providing the iron surfaces with a number of grooves formed at somewhat acute angles with the surface; the soft metal with which these become filled when it is cast over the shot or shell, serves to attach the coating firmly to the body. The other method consists in first alloying and coating the surface of iron with zinc (by the so-called galvanizing process), and then immediately covering it with the soft metal. The covering of zinc fixed, in this instance, upon the iron, becomes the medium by which the coating of lead-alloy is attached to the body of the projectile. By the latter method, therefore, a perfect juncture is accomplished between the two parts, while, by that first-named, they may be said to be fitted together accurately, or riveted together.

The different manner in which the iron and the lead-alloy are affected by considerable changes of temperature has led, in a few instances, of a very special character, to a distortion of the coatings which have been attached by the mechanical method (*i. e.*, by means of grooves) in consequence of their partial separation from the body of the projectiles. The alterations in form presented by some shells of this class, which have been exposed for a time to the effects of considerable changes of temperature, differ, however, altogether from those exhibited by a small proportion, among a number inspected, of shells, the lead-coatings of which were attached by means of zinc. On various parts of these shells, the soft metal was found to have become raised in the form of blisters, varying in size from ¼-inch to 1-inch in diameter. A large (110-pr.) shell, which had been preserved officially, as a standard pattern, since November, 1861 (having been kept in a

glass case), exhibited, upon its coated surface, in addition to numerous smaller blisters, one measuring 1·1 inch in diameter, and projecting ¼-inch beyond the surface of the shell. These projections, or blisters, were not confined to any particular position upon the different shells; neither had those projectiles, which exhibited them, been exposed to any considerable changes of temperature.

The only inference deducible from the appearance of these projectiles was, that the blisters had been produced in consequence of the generation of gas at those parts of the shells between the iron surface and the coating of soft metal, which gas had gradually accumulated to such an extent as to be placed under very considerable pressure, and, consequently, to exert, eventually, an amount of force sufficiently great to tear asunder the two surfaces of metal which had been joined by means of the zinc, and to raise up and expand the comparatively plastic alloy of lead. This influence was fully borne out by the following results of examination of the blisters.

When these were punctured, under water, a quantity of gas, existing evidently under considerable pressure, made its escape. The gas was separately collected from blisters upon different shells, and was found, in all instances, to consist of pure hydrogen.

The entire volume of gas, enclosed in the large blister specially referred to above, was carefully collected, and its volume was determined. The capacity of the blister was afterwards measured, and the results furnished by these determinations showed that the hydrogen existed at the period of examination, under a pressure very slightly exceeding ten atmospheres.

By carefully cutting through the metal surrounding the blisters, several, which had been otherwise operated upon, were removed from the shells, the internal surfaces remaining untouched. On a close inspection of these surfaces, they were all found to resemble each other closely, those of the blisters as well as those of the iron body of the shell, immediately beneath them. They presented a frosted metallic appearance, small dark patches or spots, indicative of corrosion, being visible here and there. Those of the blisters and of the iron beneath were alike coated with zinc, and their peculiar appearance, just referred to, was to be ascribed to the existence upon them of numerous small projections, such as are observed upon the surfaces laid bare when a piece of metal is fractured by a tensile strain.

It is evident, from the foregoing details, that the projections, or blisters, which have been described, had been produced by the gradual disengagement of hydrogen between the body of the projectile and the coating of lead-alloy, whereby the two descriptions of metal, joined together thoroughly in the first instance (except probably at a few minute points) through the medium of zinc, had been torn asunder and the thin intermediate zinc coating itself divided, the gas gradually creating further space for itself by expanding the envelope of soft metal which confined it.

That these results must have been due to the electrolytic decomposition of some hydrogen-compound, which had become enclosed between

the metals, is self-evident; an examination into the process of manufactures of these projectiles, aided by a few simple experimental data, appears to leave no doubt regarding the primary cause of this disengagement of gas.

The operations included in the system of coating the iron projectiles by the aid of the so-called galvanizing process, are as follow:—The cast-iron projectile, after having been turned, so as to present a perfectly clean metallic surface, is heated in an oven until its temperature approaches the fusing point of zinc; it is then plunged into a solution of sal-ammoniac, almost immediately withdrawn, and immersed in a bath of melted zinc, where it remains for about two minutes, when it is transferred to a bath of the lead-alloy with which it is to be coated. After remaining in this bath also for a period of two minutes, it is withdrawn and placed in a mould. The projectile thus treated has become uniformly covered with a thin coating of soft metal, the thickness of which is afterwards increased, by pouring a further quantity of the alloy round the coated projectile, directly it has been placed in the mould.

When the heated projectile is passed from the chloride of ammonium solution to the bath of zinc, portions of the salt remain adhering to the iron, upon its immersion in the zinc, and there is no doubt that a small proportion of water may also, occasionally, be carried along with it, so as to be brought together with it into contact with the melted metal. A small proportion of chloride of zinc is always formed at this stage of the process, by decomposition of the chloride of ammonium, in consequence of the high temperature at which particles of this salt are brought into contact with the zinc, and with oxide of zinc, small portions of which may accidentally attach themselves, at the moment of immersion, to any slight inequalities on the surface of the iron. The remarkable tendency of chloride of zinc to absorb and retain water, even at very high temperatures (the latter being only gradually expelled from it, even at the temperature of melted zinc), renders it easily conceivable that, at the time of production of the zinc-salt, any water accidentally present, besides that which results from the decomposition of the ammonium-salt by oxide of zinc, will at once be absorbed by it; there is no doubt, therefore, that any particles of chloride of zinc accidentally enclosed by the zinc-coating formed upon the iron surface, will still retain some water at the expiration of the brief period during which they continue exposed to the high temperature of the zinc-bath. Afterwards, when the coating of zinc becomes, in its turn, speedily enveloped in that of the lead-alloy, the temperature of the projectile gradually diminishing up to the termination of the process, the escape, or decomposition, of the water through the agency of heat, is speedily arrested.

Thus it is that portions of water become accidentally enclosed between the iron body and the zinc-coating of compound projectiles prepared by this system; and it is this enclosed water which afterwards suffers gradual decomposition through electrolytic agency; the accumulation

of the liberated hydrogen giving rise, eventually, to the projections or blisters in the coating of soft metal.

The surfaces laid bare by carefully cutting open many of these blisters, invariably furnished proof that chloride of zinc had been enclosed at those places, and that a basic chloride had been formed. Water removed from them a mere trace of chlorine, but, by a brief treatment with dilute acetic acid, abundant evidence was obtained of the existence of a chloride within the blisters.

It should be observed that these accidental distortions of the lead-coating on Armstrong projectiles which have been prepared by means of the galvanizing process, appear not to be of frequent occurrence, and that they do not interfere with the efficiency of such projectiles, because, even in the most striking instances, they constitute only a very small proportion of the coating of soft metal, which is in all other parts inseparably joined to the iron; and also, because the coating may, in places where it has been raised in blisters, be restored to its original dimensions by simple mechanical means.

Translated for the Journal of the Franklin Institute.

Relative Effect of different Points upon Lightning-Rods.

[Note addressed by M. Perrot, to the Academy of Sciences at Paris.]

By means of an electric machine, I charged a large metallic plate representing a cloud, until a very sensitive electrometer marked 10°. I then gradually approached to the plate, first a rod rounded at its extremity, such as M. Despretz has proposed as the terminal of a lightning rod; afterwards an ordinary lightning-rod point, and finally a very sharp point. These experiments gave me as a mean, the following results:

1. The round-pointed rod remained without neutralizing effect until it was struck, at a distance which I shall assume as the units.
2. The neutralizing action of the common point did not begin until the distance was less than 12 units.
3. At the distance of 12 units, at which the common point had no neutralizing action, the sharp point discharged the plate instantaneously.
4. The neutralizing action of the sharp point began to show itself when the distance was less than 170 units.

The neutralizing action of the fine point, therefore, extended nearly 170 times further than the striking distance, or 13 times further than the action of the common point.—*Comptes Rendus.*

Translated for the Journal of the Franklin Institute.

On the Preservation of Animal Matters in the open air.

By M. PAGLIARI.

I have the honor to communicate to the Academy (*of Sciences at Paris*), a new and very simple mode of preserving animal matter. The liquor which I employ for this purpose, is composed of alum, benzoin

and water, and differs but little from my *hæmostatic water*. A single coat of this preserving liquid applied upon the substance which is then exposed to the open air, is sufficient to prevent its decay.

Comptes Rendus.

Experiments on Steel Steam Boilers.

From the Lond. Practical Mechanic's Journal, April, 1864.

Some interesting experiments have recently been made in Prussia with steel steam boilers.—A steel steam boiler of the egg-ended shape, 4 ft. in diameter and 30 ft. in length, without flues, was tried. It had a steam drum 2 ft. in diameter and 2 ft. in height, and the plates were one-fourth of an inch in thickness. Beside it there was placed another boiler similar in every respect, excepting that the plates were of iron 0·414 of an inch in thickness. The steel boiler was tested by hydraulic pressure up to 195 pounds on the inch without showing leakage, and both the iron and steel boilers were worked under a pressure of 65 pounds on the inch for about one year and a half. During this period, the steel boiler generated 25 per cent. more steam than the iron one, and when they were thoroughly examined after eighteen months practical working, there was less scale in the steel than in the iron boiler. The former evaporates 11·66 cubic feet of water per hour; the iron boiler 9·37 cubic feet. The quantity of coal consumed was on an average 2706 pounds for the steel one in twelve hours, and 2972 pounds for the iron boiler. The plates of the steel boiler over the fire were found to be uninjured, while those of the iron one were about worn out. In Prussia several worn-out plates of iron boilers have lately been replaced with steel, which, it is stated, lasts four times as long. As steel is twice as storng as iron, thiner plates of the former may be employed for boilers, and more perfect riveting can be secured. A greater quantity of steam can also be generated in the steel boiler on account of its thin plates, and thus much fuel may be economized. Such steam boilers should engage the attention of all who make and use steam boilers for engineering and manufacturing purposes.

Proceedings of the Association for the Prevention of Steam Boiler Explosions, Manchester.

From the Journal of the Society of Arts, No. 558.

[Report of the Chief Engineer for May, 1863.]

During the past month there have been examined 257 engines—1 specially; 420 boilers—10 specially, 11 internally, 77 thoroughly, and 322 externally; in addition to which, 1 of these boilers has been tested by hydraulic pressure. The following defects have been found in the boilers examined:—Fracture, 8 (3 dangerous); corrosion, 22; safety-valves out of order, 1; water-gauges, ditto, 11; pressure gauges, ditto, 6; feed apparatus, ditto, 2; blow-out apparatus, ditto, 3; fusible plugs, ditto, 1; furnaces out of shape, 2 (1 dangerous); over-pressure, 2; (both dangerous); blistered plates 2. (1 dangerous); total, 60 (7 dan-

gerous). Boilers without glass water-gauges, 2; without pressure-gauges, 5; without blow-out apparatus, 17; without back pressure-valves, 34.

The occurrence of explosions during the past few months has been so frequent, that the reports of their details have prevented any notice of the defects found to exist in the boilers under inspection, further than that given in the monthly list as above; and, therefore, the present opportunity may be taken for some slight amplification.

Serious cases of corrosion continue to be met with at the bottom of those boilers which are set upon brick mid-feathers, running underneath them from one end to the other along the centre or keel line. In this mode of setting, any water which may fall upon the boiler, or leak from the seams, trickles down the shell, and settles on the top of the mid-feather, in contact with the plates. Also where damp exists in the flues, it easily rises through the mid-feather and reaches the boiler. Corrosion may be going on along the centre of the mid-feather and not be visible at the sides, and thus pass undetected even on careful examination—several instances of which have recently been met with.

In one case, a boiler 10 feet 5 inches in diameter, and of plates seven-sixteenths thick, was found, upon the removal of the brick-work, to be deeply channelled for a width of six inches along the bottom at the centre of the seating, no indication of which was given at the sides of the wall, nor was it detected by hammering internally, but remained unknown until the removal of the brick-work. In another boiler, the shell of which was 8 feet 2 inches in diameter, and three-eights in thickness, the plates were found to be channelled longitudinally along the centre of the mid-feather for a width of eight inches. The seating was fifteen inches wide, and the channel died out at three inches from the outside, thus giving no external sign. In a third boiler, the flues of which were damp, the whole of the plates in contact with the mid-feather were found to be corroded, and as much as a quarter of an inch in thickness eaten away. Other instances might be adduced, but the character of the injury is so similar in each case that it would be tedious. Those already given will show the grounds upon which the following recommendations are made:

First. Wherever it is practicable to do so, dispense with mid-feathers altogether, and substitute what are termed two side walls for them. Second. In those cases where the small size of the boiler forbids this, make the bearing surface of the mid-feather wall as narrow as possible. Third. Any that must be retained in use, should, in preparation for annual "thorough" inspection, be removed—at least where in contact with the transverse seams of rivets—in order to admit of complete examination.

Further cases of corrosion may be mentioned occurring to other boilers than those set upon mid-feathers.

A tubular boiler, without any external flues, was found so deeply channelled at the bottom of the shell at the transverse seams of rivets, that the plates were reduced to the thickness of a sheet of paper, and

a hole knocked through them in sounding their strength with a hammer. A second boiler, of ordinary double furnace, internally-fired construction, was so eaten away by corrosion at the first bottom plate from the front, that, as in the preceding case, a hole was made on examination, the corrosion being due to leakage from the glass water-gauges and mudhole joint, as well as to the practice of slacking the ashes while lying at the front of the boiler. In another case, where the cross wall below the front end of the boiler was as much as two feet in thickness, the plates were corroded nearly through. So great a thickness as two feet for these walls is quite unnecessary, as well as objectionable, and it is recommended that they should be removed periodically for the examination of the plates.

Several cases have been met with during the past month of injury occurring to externally-fired boilers at the parts immediately over the furnace, the plates bulging, cracking at the rivet holes, and the seams straining and leaking. One of our members has contributed a sample plate cut from a boiler of this class, which is bulged down at the solid, and cracked completely through, although the boiler was amply supplied with water; this plate is a fair sample of the danger of the externally-fired class.

A safety-valve, the spindle of which passed through a bushed hole in the cover, was found to fit so tight as to be quite fast. This bush had been fitted to prevent the inconvenience arising from the escape of steam, under the impression that a safety-valve was unnecessary, as long as the boiler was provided with a steam pressure-gauge.

A report relative to explosion, No. 9, recorded in the last month's abstract, has since been received from an engineer who examined the boiler shortly after the explosion had occurred, and from which it appears that the boiler, which was of plain cylindrical egg-ended construction, and externally fired, had rent—as is so constantly found to be the case in this class—at the transverse seams over the fire, the shell dividing into two parts, which were thrown some distance asunder.

One boiler only, and which was not under the inspection of this association, has been reported to have exploded during the last month; the explosion occurring at too great a distance from Manchester to admit of a personal investigation. Should any particulars of interest be ascertained, they will be communicated in the next monthly report. The explosion will rank as No. 10 in this year's report.

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[Report for June, 1863.]

From the Journal of the Society of Arts, No. 562.

During the past month there have been examined 340 engines—2 specially; 528 boilers—10 specially, 12 internally, 104 thoroughly, and 402 externally, in which the following defects have been found:—Fracture, 8 (2 dangerous); corrosion, 34 (3 dangerous); safety-valves out of order, 9; water-gauges ditto, 21; pressure-gauges, ditto, 9; feed apparatus, ditto, 2; blow-out apparatus, ditto, 35; fusible plugs, ditto, 13; furnaces out of shape, 4 (2 dangerous); over pressure, 2

(both dangerous); blistered plates, 3; total, 140 (9 dangerous). Boilers without glass water-gauges, 8; without pressure-gauges, 2; without blow-out apparatus, 13; without back pressure-valves, 39.

Explosions.—No. 10 Explosion :—The fact of this explosion having occurred, was stated in last month's report, but no detailed particulars had then been received. It has since been ascertained that the boiler was a plain cylindrical egg-ended one, externally-fired, and that the explosion was caused by rents commencing at the seams over the furnace, which has so frequently been found to be the case in this class of boiler, and called attention to in these reports. Two other explosions of a very similar character have happened during this month, particulars of which are given.

Nine explosions have occurred during the last month, by which eleven persons have been killed, and twenty-one others injured. One of these explosions, which resulted from collapse of the flue, and by which no injury was done either to persons or surrounding property, occurred to a boiler under the inspection of this Association; while in the remaining cases not one of the boilers was under its care. Details will be found below.

The following is the monthly tabular statement :—

TABULAR STATEMENT OF EXPLOSIONS FROM MAY 23, 1863, TO JUNE 26, 1863, INCLUSIVE.

Index No.	Date.	General Description of Boiler.	Persons killed.	Persons injured.	Total.
No. 11.	May 29.	Locomotive, . . .	1	1	2
No. 12.	" 30.	Cylindrical egg-ended externally-fired,	5	12	17
No. 13.	June 2.	Upright furnace internally-fired, .	0	0	0
No. 14.	" 13.	Details not yet ascertained, . .	1	5	6
No. 15.	" 13.	Ordinary single flue, or "Cornish" internally-fired, . . .	0	0	0
No. 16.	" 14	Cylindrical egg-ended externally fired,	1	0	1
No. 17.	" 15.	Details not yet ascertained, . .	2	3	5
No. 18.	" 15.	Marine, . . .	1	0	1
No. 19.	" 26.	Details not yet ascertained, . .	0	0	0
	Total .	. . . . .	11	21	32

No. 11 Explosion occurred to a boiler of a locomotive engine while running with a passenger train. Between fifty and sixty persons were injured and four killed. This result was not occasioned, however, by the explosion only, but principally by the train running off the line. Whether the engine leaving the rails was the cause or the effect of the explosion, is an investigating question, and one now undergoing strict investigation. All the facts likely to prove of value to steam users generally, which may be elicited with regard to this explosion, will be given to the members of the Association at the earliest opportunity after the close of the inquiry. The only injuries directly attributable to the explosion, are those which happened to the engine-driver and

fireman, both of whom are severly scalded, the latter having died in consequence.

No. 12 Explosion, from which five persons were killed and twelve others injured, took place at an iron-works. The boiler in question was not under the care of this Association, was personally examined shortly after the explosion happened, and found to be of cylindrical egg-ended construction, having an internal flue of horseshoe-shape, both the inlet and outlet of which passed through the further end of the boiler, the remainder of the flue being quite independent of the shell, and thus not forming any longitudinal tie from front to back. The boiler was externally-fired, the flame passing underneath the shell, and then entering the flue at one end of the horseshoe, and escaping to the chimney through the other. The length of the shell was twenty-eight feet, the diameter eight feet six inches, and the thickness of the plate seven-sixteenths, while the blowing off pressure was about 40 lbs.

The boiler had rent completely into two parts at the fourth transverse seam from the front end, the larger portion of the shell flying forwards in a straight line from its seat, turning a summersault in its course, and landing in a position quite the reverse of its original one; the egg-ended pointing to the brick-work seating, and the open one from it. The smaller portion had flown to a much greater distance than the other, and not, as is usually the case, in a direction immediately opposite, but at right angles to it. A sister boiler working alongside, and connected to the one in question, was moved laterally, sufficiently so to disturb the brick-work seating and break the steam-pipes, though not to unseat it altogether.

With regard to the cause of the explosion:—The boiler was fifteen years old, the plates over the furnace had already been repaired, and it was stated that the seams at that part had been observed to be leaking only a quarter of an hour before the explosion took place: while, in addition, the shell was found to be patched in several places, and the plates cracked from the rivet holes to the edge. It is concluded, therefore, on consideration of all the circumstances, that the boiler could not have been in good condition, the correctness of which it is thought derives some corroboration from the fact, that the boiler alongside was found at the time of making this examination, to be also leaking at the seams over the furnace, and that considerably, although not under pressure. An examination of the fractures, as well as a consideration of the direction in which the parts had flown, led to the conclusion that the rent had commenced at a longitudinal seam of rivets, extending for some two or three plates over the furnace. The rent ran along as far as this longitudinal seam extended, and when met by a plate crossing it, or "breaking-joint," as it is termed, then developed into a transverse rent, and completely severed the shell in two. It is thought that the fact of this longitudinal rent in the furnace-end of the shell being situated on one side of the centre, or "kell-line," accounts for that portion having been blown laterally, and that the upward direction which it had evidently taken, had caused the summersault of the remaining and larger portion. The explosion, therefore, is

attributed to the imperfect condition of the boiler, and although such defects would not be dangerous in a suitably-constructed double-flued, or "Lancashire" boiler, which is always internally-fired, they are generally found to be fatal in those boilers which are fired externally; while in the present case the effect was aggravated by the fact of the seams of rivets over the fire being in line, and the diameter of the shell being as much as eight feet six inches.

No. 13 Explosion, by which no one was injured or the surrounding property damaged, occurred to a boiler under the inspection of this Association, the particulars of which are as follows:—

The boiler was an upright furnace one, working in connexion with two others of similar construction to itself. It was heated by the flames passing off from a furnace employed in preparing heavy forgings, the flames passing through an internal tube in the centre of the boiler, which ran directly from the top to the bottom. The extreme height of this internal flue was twenty-six feet two inches, but it was not of one diameter throughout. In order to admit of a brick-work lining to guard the flue above water line, the upper part was made of a larger diameter than the remainder, and attached to it by a flanged plate, which formed a "set-off," or shelf, on which the brick-work rested; again, the lower portion of the tube had a bell-mouth at the bottom, to afford an easy entrance for the flame. The length of the upper part was 11 ft. 4 in., and the diameter 3 ft. 3 in.; the length of the intermediate portion was 10 ft. 4 in., and the diameter 2 ft. 6 in., while the length of the bell-mouth was 4 ft. 6 in., and the diameter at the base 3 ft., the thickness of the plates being three-eighths of an inch throughout, and the blowing-off pressure 55 lbs.

The explosion, which did not in any way disturb the original position of the boiler, resulted from collapse of the internal flue tube, the collapse being confined to the intermediate portion just described, which it rent about the middle of its length.

A tube of such small dimensions as those just given, namely, only 10 ft. 6 in. in length, and 2 ft. 6 in. in diameter, made of plate three-eighths in thickness, if of good material and workmanship as this one was, would be amply sufficient for a pressure of 55 lbs., if working under ordinary circumstances. This would suggest the conclusion that the water supply had been allowed to run short, but no positive indications of the plates having been over-heated appeared upon examination, though this may, however, have taken place on previous occasions without its being known. On account of the height of these upright furnace boilers, the glass gauges became inaccessible, and the one in question was fitted with two gauge-taps only, carried down by means of syphon pipes to within reach from the floor. Thus the water could sink below the proper level without affording any external indication, and would consequently pass unknown, should the gauge-taps be neglected. This may have happened without any immediate collapse of the tube taking place, although the flue would be materially weakened by it, and rendered liable to give way some time after in consequence. It is impossible to say whether the flue tube was getting out

of shape or not, since the boiler had been in such constant work, that no opportunity was afforded the Association of making an "internal" and "thorough" examination for upwards of three years, This may not, therefore, be an improper time for calling attention to the importance generally of having spare boilers, so that a suitable opportunity may be afforded for examination, as well as for cleaning and repair. The boiler was found to be heavily incrusted with hard scale, which must considerably have tended to the over-heating and weakening of the flue, to which these vertical boilers are always prone, from the tendency of the ascending steam to cling around the tube and prevent the contact of the water. The inaccessibility of the gauges and fittings of these vertical boilers, on account of their height, is another disadvantage connected with them, and, indeed, a thoroughly good and safe furnace boiler must still be considered as a desideratum.

No. 16 Explosion happened at an iron-works, to an externally-fired boiler 40 ft. long, 8 ft. in diameter, made of plates seven-sixteenths of an inch thick. The shell of the boiler gave way immediately over the furnace, the fireman being scalded to death from the stream of hot water issuing from the rent. The boiler had been repaired at this part, by putting on a new plate two months previous to explosion, and it was at this plate that the rent occurred.

This boiler, which was not under the charge of this Association, was not personally examined on the occurrence of the explosion, but an engineer who inspected it shortly after, has kindly furnished the following particulars:—The plate ripped open through the solid metal in two places, the rents being about fifteen inches long and one inch wide, while the parts surrounding it were a good deal cracked and the seams patched, so that the bottom of the boiler was evidently in a very defective state. The ruptured plate was about seven-sixteenths of an inch thick, and did not appear of very good quality, as if not thoroughly welded in rolling; but the fractures were not, properly speaking, "blisters," since the whole thickness of the plate had come down at once. In addition to the inferior character of the plate, the boiler was heavily coated with incrustation, and this had accumulated at the bottom for a depth of three inches just over the fracture, and extended for a space of four feet by two feet. This mud had hardened so much that the water and steam ploughed but a small hole through it in rushing out. There can be little question that this coating of mud had kept the water away from the plate, and thus lead to its being over-heated, from which it gave way. There was plenty of water in the boiler at the time of the rupture.

It will be clear that it is scarcely possible for such a cake of sediment to have formed upon the furnace crown of an internally-fired boiler, and also that an efficient blowing-out apparatus would have prevented the accumulation in a great measure, if not altogether, and thus that the explosion was due to the dangerous character common to all externally-fired boilers, coupled in this case with neglect.

For the Journal of the Franklin Institute.

The Sphere, Cone, and Cylinder.

In an old book, entitled "The Elements of Euclid, with select theorems out of Archimedes," printed in London in 1719, I find data, which, by the aid of our tables of areas of circles, will facilitate computations of the surfaces and solidities of spheres, spherical segments and sectors, and the comparative superficies and solidities of inscribed and circumscribed cylinders and cones.

1st. To find the surface of a sphere:—"Let the greatest circle of the sphere be measured, and let it be multiplied by 4." It is evident from this that the area of a circle whose diameter is double that of the given sphere must be equal to the surface of the sphere. To shorten the work of calculation, double the diameter of the given sphere, and from the tables take the circle area corresponding for the surface of the sphere.

2d. To find the solidity of a sphere:—"If the 6th part of the diameter be multiplied by the surface of the sphere, there will arise the solidity of the sphere." Doubling the given diameter and taking its 6th part can be done in the mind in most cases, while that part left for the pencil is simply the multiplication of the tabular area by the 6th part of the diameter; thus, suppose a 15-inch sphere is given to find the solidity.

Area of 30-inch diameter = 706·86 = surface of sphere,
and 706·86 × 2·5 = 1767·15 = solidity required.

3d. To find the surface of a spherical segment or zone. It is proven, that the surface of a spherical segment or zone, is to the entire spherical surface of which it is a part, as the height of the segment is to the diameter of the sphere. From this proportion the rule is plain. Thus:—Multiply the entire spherical surface by the height of the segment and divide by the diameter of the sphere.

4th. To find the solidity of a spherical segment or sector. Multiply the spherical surface of the sector by the third part of the radius for the solidity required, and for a segment find the solidity of the sector of which it forms a part, then deduct the cone which lies between the base of the segment and centre of the sphere, if the segment be less than a hemisphere, and add it thereto if the segment be greater.

5th. "The superficies of a right cylinder (one whose height and diameter are the same,) circumscribed about a sphere is equal to the surface of the sphere." The cylindrical surface only is here meant.

"If a cylinder and inscribed sphere be cut by planes perpendicular to the axis, each segment of the cylindrical surface will be equal to the corresponding segment of the sphere."

From this property the 3d rule above is evident.

6th. "A right cylinder is both in solidity and the whole superficies to the sphere about which it is circumscribed, as 3 to 2."

7th. "The superficies of a sphere is to the whole superficies of an equilateral cone circumscribed about it as 4 to 9."

8th. "The whole superficies of an equilateral cone circumscribed about

a sphere is quadruple of the whole superficies of an equilateral cone inscribed in the same sphere, and the solidity of the former cone is eight-fold that of the latter."

9th. "A sphere hath that proportion to an equilateral inscribed cone as 32 to 9."

10th. "A sphere hath the same proportion both in respect of solidity and surface to the equilateral cone circumscribed about it which 4 hath to 9."

11th "A sphere, a circumscribing cylinder and a circumscribing equilateral cone, both with respect to solidities and whole superficies, bear the continued proportion, respectively, to one another, as 4 : 6 : 9."

Archimedes set great value upon his discovery of the sesquilateral proportion of the right cylinder and internal touching sphere, as enunciated in the 6th property above; such that he would have a figure of it engraved upon his tomb.

There is one ratio for the three.

It is a matter of argument why he should prize this above other discoveries which he made, and above machines put into practical use, and which would seem to have given him a wider fame than the discovery of any abstruse mathematical relations or inherent properties of lines and surfaces.

But so it was, he valued the discovery of purely mathematical fact far above any practical display of prepared matter, or mechanical combinations, whatever may have been the efficiency of its performance or the prodigiousness of the force which it developed.

Archimedes' discovery received a very important as well as interesting addition at the hands of the learned Andrew Tacquet, the author of the old book in question, and the two combined are given in the 11th property above with a figure, inscription, and translation.

It is singular indeed that bodies whose surfaces and sections present so many difficulties in practice should in themselves, as wholes, bear so simple a relation, one to another. Y.

On the Employment of Burning Wire, as an Illuminating Agent, Especially for Photographic Purposes. By PROFESSOR ROSCOE.

From the London Practical Mechanic's Journal, April, 1864.

Professor Roscoe exhibited the light emitted by burning a portion of a fine specimen of pure magnesium wire 1 mm. in diameter and 10 feet long, which had been manufactured by Mr. Sondstadt. Professor Roscoe remarked that it afforded him great pleasure to be able to state

that a suggestion made by Professor Bunsen and himself in their photochemical researches, and printed in the Philosophical Transactions for 1859, page 922, was about to be practically adopted. Mr. Sondstadt is now commencing to manufacture the metal magnesium on the large scale, and the first important application of the metal is the employment of burning magnesium wire as an illuminating agent, especially for photographic purposes. In the researches above mentioned, Professor Bunsen and the speaker had examined the photochemical action of the sun compared with that of a terrestrial source of light, and for the purpose of this comparison they chose the light evolved by the combustion of magnesium wire. They showed that a burning surface of magnesium wire which, seen from a point at the sea's level, has an apparent magnitude equal to that of the sun, effects on that point the same chemical action as the sun would do when shining from a cloudless sky at a height of 9° 53′ above the horizon. On comparing the *chemical* with the *visible* brightness of these two sources of light it was found that the brightness of the sun's disk as measured by the eye when the sun's zenith distance was 67° 22′, is 524·7 times as great as that of the burning magnesium wire, whilst, at the same zenith distance, the *chemical* brightness of the sun is only 36·6 times as great. Hence the value of this light as a source of the chemically active rays for photographic purposes becomes at once apparent. The extract from the memoir referred to is as follows:—

"The steady and equable light evolved by magnesium wire burning in the air, and the immense chemical action thus produced, render this source of light valuable as a simple means of obtaining a given amount of illumination expressed in terms of our measurement of light. . . . . The combustion of magnesium constitutes so definite and simple a source of light for the purpose of photochemical measurement, that the wide distribution of this metal becomes desirable. The application of this metal as a source of light may even become of technical importance. A burning magnesium wire of the thickness 0·297 millimetre evolves, according to a measurement we have made, as much light as 74 stearine candles of which 5 go to the pound. If this light lasted one minute, 0·987 metre of wire, weighing 0·1204 grm., would be burnt. In order to produce a light equal to 74 candles burning for 10 hours, whereby about 20 lbs. of stearine is consumed, 72·2 grms. of magnesium would be required. The magnesium wire can be easily prepared by forcing out the metal from a heated steel press having a fine opening at bottom; this wire might be rolled up in coils on a spindle, which could be made to revolve by clock-work, and thus the end of the wire, guided by passing through a groove or between rollers, could be continually pushed forward into a gas or spirit-lamp flame in which it would burn."

Professor Roscoe stated that great credit was due to Mr. Sondstadt for the able manner in which he had brought the difficult subject of the metallurgy of magnesium into the present satisfactory position, and expressed his opinion that, even in photographic purposes, the appli-

cation of the metal will prove most important. Mr. Brothers, Mr. Parry, and other photographers present, corroborated Dr. Roscoe's opinion respecting the value of such source of light for photography. Since the meeting Mr. Brothers made an experiment upon the magnesium light, which he reports as follows:—

"The result of an experiment I have just tried is that in 50 seconds with the magnesium light I have obtained a good negative copy of an engraving—the copy being made in a darkened room. Another copy was made in the usual way in daylight, and in 50 seconds the result was about equal to the negative taken by the artificial light. The sun was shining, but there was a good deal of fog in the atmosphere."

To the Editor of the Journal of the Franklin Institute.

SIR:—The propriety of introducing the word "equivalent," in patent claims, has been a subject of much discussion and difference of opinion among both patentees, and the officials of the Patent-Office.

The following argument was written with the hope of obtaining an official decision which would set the question at rest for the future. It was submitted to the Commissioner of Patents, who, by granting the patent, acknowledged the pertinence of the grounds advocated in the argument.

—

Argument in the matter of the Application of R. HEYS *for Letters Patent for Variable Valve Motion for Steam Engines.*

To the Honorable Commissioner of Patents.

Sir:—The contents of the official letter of December 7th, 1863, have been carefully perused, and the suggestions of the Examiner in charge of this case duly considered.

The official letter contains the following:—"It is well understood that the law regards real equivalents as secured to you without the use of the language (the equivalents to the same) in your claim. It is therefore regarded as superfluous."

I regret that my opinion on this point is at variance with that of your able Examiner.

The word "equivalent," in the claim of a patent, is, according to my humble views, not only not superfluous, but in very many instances a word of the most vital importance, a word, the insertion of which an applicant for a patent has a right to insist upon, unless the Office can give references of a character which demands the limiting of the claim to a special combination and arrangement of parts.

When an inventor presents an application for a patent for an improvement on the invention of another, it is the very proper practice of the Patent-Office, to require the applicant to word his specification in such terms as to acknowledge the rights vested in his predecessor.

So also has it been the practice of the Patent-Office, to allow broad claims for inventions for a novel character, and such words as *equivalent* and *substantially*, have been hitherto allowed for the express purpose of adding breadth to a claim.

The Office has invariably attached importance to the word equivalent, for in hosts of instances, specifications have been returned for the erasure of that word, because it rendered claims so broad as to conflict with those in prior patents, while in almost as many instances the insertion of the word has been permitted.

It is scarcely correct to say that "it is well known that the law regards real equivalents as secured without the use of the word equivalent in a claim:" this may be well known to those versed in patent matters, but a lengthened experience as a patent attorney has convinced me that the public is very far from being possessed of this knowledge, and for this reason it is respectfully contended that the word should be allowed whenever the nature of the invention will permit its insertion.

What better argument can be advanced in support of the use of this word than that the law allows it? What better guide can an applicant follow in framing his claim than the law?

Whatever strength the word equivalent may impart to a patent, and there can be no doubt that the word does impart more or less strength, there is an important reason why the word should be allowed on all appropriate occasions. Our community is unfortunately infested with a class of men who are a terror to meritorious inventors. I allude to the pirates or counterfeiters, who no sooner become aware of the value of an invention, which may be the successful result of long study, laborious research, and elaborate experiments, than they set whatever wits, or rather whatever low cunning they may have to work, with the view of infringing on the successful inventor's rights, evading his patent, or to use more simple and appropriate language, picking his pockets. Where is there a patent attorney of any lengthened experience who cannot count these pirates by the score, who cannot call to mind hundreds of instances in which these copyists have asked advice in somewhat such terms as follows:—"Mr. H., a patent has recently been granted to Mr. B., for an improved——. This is his claim; it is a very valuable patent, and there is a great profit in the article for which there is a great demand: I propose to make a somewhat similar invention; I use part of Mr. B.'s patent, but I substitute other devices for part of what he claims. Don't you think, Mr. H., that by so doing I can evade the patent granted to B., especially as his claim is limited to the particular arrangement or combination of parts?"

If all patent attorneys would treat such characters as they ought to be treated, that is, make such physical demonstrations as would insure their precipitate retreat, the evil might be remedied; unfortunately, however, the acts of these parasites are in too many instances encouraged. The best remedy, however, rests with the Patent-Office.

These piratical interlopers with a species of short-sighted cunning

in almost every instance, base their operations on the wording of the claim of the patentee whose rights they propose to invade, and lay their plans accordingly.

If they peruse a carefully framed claim with the word *equivalent* or *substantially* appropriately introduced, they approach it with caution, they look upon it as property well fenced round, and in most cases abandon the idea of committing the premeditated act of piracy as too dangerous a proceeding.

If the meritorious inventor can by the use of the simple word *equivalent* in his claim keep the vermin at arms length, if the law allows the use of the term as it certainly does, if prior inventions present no bar to the introduction of the word, for heaven's sake let the inventor have it.

An applicant's claim should be framed in plain and concise terms; such terms as the most untutored mind can understand. "It is the duty," said Judge Story (Wyeth *vs.* Stone,) "of the patentee to sum up his invention in clear and determinate terms, and his summing up is conclusive upon his rights and title." "If the inventor (says Judge Grier) sums up the particulars of his invention, he is confined and held to such summary, and his patent must stand or fall by it."

If an invention consists of three things, A, B, and C, in combination with a fourth, which I will designate by the letter D, and if the three things are absolutely necessary to constitute the main features of the invention, while it is palpable to both the inventor and others that many things might be used to develop these features in place of D, why should not the inventor say so in his claim? why should he not say I claim A, B, and C, in combination with D, or its equivalent? Why should the Patent-Office object to such a claim because the law assumes the word equivalent to be understood although not expressed?

Is the praiseworthy and industrious inventor to be rewarded with a patent concluding with a claim which every one possessing common sense can understand, or is he to have a patent which appears to the envious and covetous pirate like an English act of Parliament, through which a member declared he could drive a coach and six, a patent which may form the nucleus of expensive lawsuits, a patent, the true meaning of which cannot be ascertained without an appeal to the law, or without resorting to the costly array of judges, juries, and venal professional experts?

In relation to this subject there is another important point to be considered.

It is an undoubted fact that there is a large, and I may add a respectable portion of our community who look upon patents and patent property as too precarious to meddle with, who consider the dealing in patents as closely allied to lottery transactions and gambling.

Ask these men the cause of their opinions, and in many instances you will find that either they or their friends have had their fingers bitten (to use a common phrase) by patents, their rights invaded, their profits squandered in lawsuits and their peace of mind destroyed by fruitless litigation.

The continued prosperity of the Patent-Office depends upon the value of patent property; the depreciation of this property soon tells on the receipts of the Office. If such claims only are allowed to an inventor as will leave his property open to the incursions of avaricious copyists, if the patents cannot be interpreted or sustained without resorting to expensive legal interpretations, patent property must soon become a drug in the market, inventors must cease to ply their vocations, the progress of the arts must be impeded, and not only the Patent-Office but the public at large must be sufferers.

In decrying the pirates who prey upon the industrious and ingenious inventors, let it not be supposed that I desire to confound these pests with a class of men who base their inventions on those of others, but are willing to admit the rights of their predecessors and to limit their claims accordingly. These men who may be termed real inventors are almost as important and valuable members of the community, as the originators, for it is by continued improvements only that true perfection can be arrived at, and I would here remark that patents of this class drawn up in proper candid terms are, as far as my experience goes, more valuable to their owners than such as are surreptiously obtained, and concocted from the brains of others.

To return to the present application which has given rise to the above remarks. It will be found that Heys claims the valve spindle D, link E, eccentric rod G and arm F, in combination with a weighted lever L and link *h*, or their equivalents. Now it is quite evident that D, E, G, and F, are absolutely necessary to carry out the applicant's intentions, and therefore any equivalent to them is not referred to: it is equally evident that many devices might be used in place of K and *h* for causing the motion of the governors to be communicated to the link D; for instance, a weighted lever without the link *h*, but having a roller at the end to bear up against the underside of the arm F, might be used for the purpose, or the weighted lever K and link *h*, might be dispensed with, and the link E suspended from a weighted chain passing over a pulley to be acted on by the governor, in fact, other devices will suggest themselves to expert mechanics.

If the combination of the parts D, E, G, and F operating in conjunction with each other as described is new, I can see no reason why the Office should insist upon the striking out of the words "*or their equivalents*," as applied to the other parts K and *h*, and thus put the applicant in possession of a patent which the public would declare to be weak, which would be liable to attacks from unscrupulous men, and would be more of an injury to the patentee than a benefit.

Although my remarks have been extended beyond the usual limits, and although my views have been expressed in perhaps unnecessarily urgent terms, I am satisfied that the Office will not consider me to be actuated by any spirit of fault-finding, or the desire to assume a dictatorial position.

Whatever errors there may be in the above views on an important subject, and the Office may be able to convince me that I have erred in some respects, they have not been coined for an especial purpose,

but have been suggested by experience and by intimate knowledge of the opinions and wants of inventors.

In conclusion let me direct the attention of the Examiner in charge to the recent decision by the Board of Examiners in Chief, in the case of J. S. Mason's application for a patent for a design for a label, a decision which I am satisfied was prepared after the most careful consideration by the gentlemen composing that board.

I am, very respectfully, yours,

HENRY HOWSON, Attorney for R. Heys.

English vs. *Swedish Iron.*

From the London Builder, No. 1088.

Experiments of an important nature have just been made at the fortress of Carlberg, in Sweden, upon the respective merits of armor-plate made in England, France, and Sweden. Messrs. John Brown & Co., of Sheffield, sent two plates, one 12 feet by 2 feet 6 inches, and one 6 feet by 3 feet 8 inches. Messrs. Petin, Gaudit & Co., of Lyons, sent two plates, each of 7 feet 6 inches by 3 feet 3 inches. The Montala Iron-works Company, of Sweden, sent two plates of 12 feet by 2 feet 6 inches, and one 6 feet by 3 feet 8 inches. All the plates were 4½ inches in thickness, and then bolted to a teak target backed with iron plating, and supported by a massive stone pier. The two upper plates in the target were the French, and each was secured by 11 bolts. The next plate below was the longest, Swedish, and this was secured by 29 bolts. Below this was a tier of two short plates, one Swedish and one English, each secured by 24 bolts, and the lowest plate was a long English, secured, like the Swedish, by 29 bolts. Each plate received six shots from the ordinary 68-pounder naval gun. The French and Swedish plates broke to pieces, and the English plates remained uninjured and free from cracks. The shots used were of Swedish iron, and exhibited great toughness as compared with the shots used in the English service—the core or centre of the shot, after striking, being of double the weight of the core of the English shot.

Army and Navy Gazette.

FRANKLIN INSTITUTE.

Proceedings of the Stated Monthly Meeting, March 17, 1864.

William Sellers, President, in the chair.

John H. Towne, Fairman Rogers, } Vice Presidents.
Robert Briggs, Corresponding Secretary. } present.
John F. Frazer, Treasurer.
Washington Jones, Recording Secretary.

The minutes of the last meeting were read and approved.

Letters were read from the Royal Geographical Society, London; l'Academie Royale des Sciences de Lisbonne, Portugal; Capt. J. M. Gillis, U.S.N., United States Naval Observatory, Washington, D. C.

Donations to the Library were received from the Royal Astronomical Society, the Royal Geographical Society, the Society of Arts, and the Chemical Society of London; l'Ecole des Mines, Paris, et la Société Industrielle de Mulhouse, France; l'Académie Royal des Sciences de Lisbonne, Portugal; the Canadian Institute of Toronto, and the Natural History Society, Montreal, Canada; the U.S. Naval Observatory, the Hon. Wm. D. Kelley, and F. Emmerick, Esq., Washington, D.C.; the Board of Water Commissioners, Jersey City, N.J.; the Young Men's Association, Milwaukee, Wisconsin; and from Dr. T. S. Kirkbride, Wm. J. Mullen, Esq., John P. Whipple, Esq ,U.S.N., Prof. John F. Frazer, and A. M. Spangler, Esq., Philadelphia.

The Periodicals received in exchange for the Journal of the Institute, were laid on the table.

The Treasurer's report for February was read.

The Actuary reported that the following Standing Committees have organized by electing their chairmen and appointing the time for holding their stated meetings.

Committee.	*Chairman.*	*Time of Meeting.*	
On Library,	George Harding,	1st Tuesday	Evening,
" Exhibitions,	T. Morris Perot,	1st Wednesday	"
" Arts and Manufactures,	John H. Cooper,	1st Friday	"
" Cabinet of Minerals,	Elias Wildman,	2d Monday	"
" Cabinet of Models,	William B. Bement,	2d Monday	"
" Science and the Arts,	John C. Cresson,	2d Thursday	"
" Meetings,	Henry Howson,	3d Thursday	"

The Special Committee on the revision of the By-Laws, presented their report, which was read and accepted.

The Special Committee on the Weights, Measures, and Coinage of the United States reported their progress, and were continued.

A Committee appointed by the Board of Managers, reported a draft of the amendments proposed to be made in the Charter of the Institute, which was discussed and several amendments proposed; when a committee was appointed to prepare an amended Charter of the Institute, in accordance with the memorial just adopted.

On motion, it was

Resolved, That the Institute do hereby approve of, and direct the President to affix and attest the seal of this corporation to the petitions which have just been read, and to transmit them to the Senate and House of Representatives, respectively, in such manner as he shall deem proper.

Resignations of membership in the Institute by six gentlemen, were read and accepted.

Candidates for membership in the Institute (10) were proposed, and the candidates proposed at the last meeting (6) were duly elected.

The President read a letter from the Hon. Gideon Welles, Secretary of the U.S.N., requesting the Institute to appoint a committee of three members to act jointly with like committees to be appointed by the Navy Department and by the National Academy of Sciences, to

conduct, witness, and report upon, experiments which may be agreed upon by the commission on the expansion of steam.

On motion, the President was authorized to appoint the committee to act on the joint committee, as requested by the Navy Department, when he named the following gentlemen, who were approved:

Committee.—Messrs. John H. Towne, J. Vaughan Merrick, and Richard A. Tilghman.

Mr. Chase continued the abstract of his papers on "Tides of Rotation," and made some remarks respecting the alleged connexion between the variable rate of the earth's rotation and the mean temperature of given parts of its surface.

Mr. Colburn's inquiry into the nature of heat suggests some interesting speculations concerning other efforts of rotation than those that can be measured by the barometer. Recognising the impossibility that the sun should warm the whole solar system, as a simply incandescent body,—the improbability that its heat should result from continuous combustion, and the probable approximate uniformity of temperature in the upper regions of the atmosphere, in summer and in winter, by day and by night, Mr. Colburn looks for the principal sources of heat to the earth itself. He supposes, 1, that the solar attraction tends to draw into closer proximity the particles of air on the heated side, and to separate them on the night-side of the earth, thus producing heat of compression, and cold of expansion. 2, that the change of eastward velocity from 67,000 miles per hour at midnight, to 69,000 miles at noon (*sic*), necessarily produces a conversion of motion into heat, and of heat into motion. And, 3, that if the earth is moving in a resisting medium, by which it is so retarded that it approaches the sun at the rate of 1,000,000 miles in 3,000,000 years, its "lift" involves the annual abstraction of heat-force equivalent to 752,665,108,390,000 horse-power!

The third hypothesis has been often broached; the indications of a resisting ether, which, as has been seen, are furnished by the hourly barometric means, may, perhaps, yield the data for its final verification or rejection. The supposed separating effect of the sun's action in the most remote portions of the atmosphere, is so problematical, that it seems hardly deserving of any consideration, and even if it existed, it is difficult to understand how it could produce a difference of more than a fraction of a degree in the range of the thermometer. The alternate acceleration and retardation of orbital velocity, can produce no *accumulation* of heat to supply any loss that may arise from radiation into space, but it must modify the *distribution* of heat throughout the day in a manner that may be readily calculated. The available data are not sufficient to furnish us with complete results, but they give curious approximations that seem to open a wide field for profitable investigation.

"Sir John Herschell finds the direct heating effect of a vertical sun at the sea level, to be competent to melt ·00754 of an inch of ice per minute; while according to M. Pouillet, the quantity is ·00703 of an

inch."* Taking the mean of these two estimates (·00728 in.), multiplying by the latent heat of water, (142·6° F.), and dividing by the number of cubic ins. in 1 lb. of water (28), we obtain $\frac{\cdot00728\times142\cdot6}{28} =$ ·037076 units of heat received per minute on each square inch of the earth's surface that is exposed to a vertical sun. The weight of the aerial column being 15 lbs., and its ratio of specific heat ·25, the maximum effect of the direct solar rays is sufficient to heat the whole atmosphere $\frac{\cdot0371}{15\times\cdot25}$ per minute, or 7·12° F. in 12 hours.

Now, in consequence of the earth's rotation, the difference of atmospheric "lift" between noon and midnight, is 182,336 feet per minute. The average difference for the twelve hours, is one-half as great. "Rapid rotation, without friction or resistance, cannot in itself alone be regarded as a cause of light and heat;"† but we have found in our barometric investigations, that the ratio of the half-daily velocity of rotation to that which would be conferred by twelve hours action of terrestrial gravity, is ·00109, which may be regarded as the modulus of heat-producing resistance. If we multiply the average difference of lift by the weight of the atmosphere, and by the effective resistance, dividing the product by the ratio of specific atmospheric heat, and the number of foot-pounds raised by a unit of heat, we obtain $\frac{91168\times15\times\cdot00109}{770\times\cdot25} = 7\cdot74°$ F. as the amount of heat communicated to the air by rotation between midnight and noon, and abstracted between noon and midnight.

The theoretical barometric lift is, as we have seen, ·00219 of the entire weight of the atmosphere. Estimating the height of the aerial column when reduced to uniform surface density, at 24,000 feet, the heat-producing disturbance that is indicated by the barometer, is represented by a lift of 15 lbs. on each square inch to a height of ·00219×24000 feet. The quarter-daily disturbance from this cause is, therefore, $\frac{24000\times15\times\cdot00219}{770\times\cdot25} = 4\cdot1°$ F.

It is more than likely that each of these results will require important modifications when the entire influence of the several conditions of the problem is better understood. I have thought it proper to present them in their present crudity, in order to show the true points of departure, and to prepare the way for some further considerations.

Whatever other heat-disturbing causes there may be, there can be little doubt that the three we have just been considering are the most important. Dividing the astronomical day into four quadrants, and representing the solar effect by S, rotative by R, and barometric by B, it will readily be seen that the several positive and negative influences must be distributed as follows:

* Tyndal, Heat considered as a Mode of Motion. N. Y. edit. p. 431.
† Dr. J. R. Mayer.

	S.	R.	B.
From 0h. to 6h.	+	—	—
" 6h. to 12h.	—	—	+
" 12h. to 18h.	—	+	—
" 18h. to 0h.	+	+	+

The tables of average temperature at any given place would therefore furnish us with four equations for determining the value of each of the disturbing elements, provided those that are unknown were so insignificant as to be safely neglected. The effects of these unknown disturbances are confined within certain limits that can be pretty satisfactorily determined.

Our discussion of the barometric fluctuations demonstrated a tendency of inertia to retard the effects of rotation, so that the mean daily altitudes are found nearer to 1h., 7h., 13h., and 19h., than to 0h., 6h., 12h., and 18h. A like tendency is discernible in the thermometer.

There are three, and only three, quadrantal divisions of the day, commencing respectively at 0h., at 1h., and at 2h., for which we could obtain approximate positive values of S., R., and B. The maximum solar effect is deduced from the first, and the minimum from the third of these divisions; while the maximum rotative and barometric effects are exhibited in the third, and the minimum in the first division.

The nearest average temperatures are found in the third division, as is shown below.

Average of Temperature at 2h., 8h., 14h., and 20h., and of the entire day.

Station.	Mean of the four hours.	Daily mean.
At Girard College, . .	52°·1	52°·1
At St. Helena, . .	61°·65	61°·69

The following table presents all the co-ordinate positive values of S., R., and B., that can be obtained from the Girard College and St. Helena means.

Station.	Dividing at								
	0,6,12,18 h.			1,7,13,19 h.			2,8,14,20 h.		
	S.	R.	B.	S.	R.	B.	S.	R.	B.
	Per ct	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
Girard College,	45·92	41·32	12·76	31·3	49·5	19·2	13·8	63·2	23·
St. Helena, .	25·97	42·96	31·07	15·8	46·7	37·5	5·6	56·6	37·8

The percentages of the calculated values correspond very nearly with the means of the earliest Girard College and St. Helena values.

	Calculated.	Percentage.	Mean Percentage.	Limits.
S, .	7°·12	37·6	35·95	5·6 45·92
R, .	7°·74	40·8	42·14	40·8 63·2
B, .	4°·1	21·6	21 91	12·76 37·8

It may be inferred from this comparison that the rotation element of daily heat is least affected, and the solar element most affected by extraneous causes (of which moisture is probably the chief); that the first division gives the best, and the third division the poorest results; that the proportion of thermometric variation which is attributable to rotation is between ·4 and ·5 of the average total daily variation, and that the most difficult element to determine satisfactorily is S., which is modified by many local disturbing influences, such as the nature of the soil, amount of vapor, clouds, altitude of the sun, &c. &c.

Prof. A. L. Fleury read the following papers:

I. *On Carbonic Acid and Artificial Spring Waters.*

It is only a few years since the value of Aërated Waters—waters impregnated with Carbonic Acid which holds many otherwise insoluble substances in perfect solution—has become better appreciated, and as spring and warm weather will soon begin to make their appearance, I beg your attention for a few moments to a new improvement in the so-called Transportable Fountains.

Everything that tends to preserve and improve our health, deserves, or better said, should, by right, be entitled to our consideration. For the last year, Messrs. Schultz & Walker, 133 4th Avenue, in New York, supplied the public with a superior article of Carbonic Acid, and Artificial Spring Waters, such as Selters, Vichy, Kissingen, Carlsbad, Püllna, Iron Water, Citrate of Magnesia, and others in the fountains here exhibited, at prices varying from 15 to 25 cents for contents of bottle. These fountains have been imported from France at a great cost; every one is tried with a pressure of 15 atmospheres before it is allowed to leave the factory. Mr. Carl Schultz, of the U. S. Assay Office in New York, remarked to me, that notwithstanding his numerous inquiries he has not yet been able to have these bottles made in this country, and he is very desirous to reduce the price of the fountain, which now with the high price of gold is over $2 per fountain. I have here a few pieces of the glass of which the fountains are composed. Carbonic acid has recently found a new application for the relief of *gout*, and as a soothing medium for the pain produced by exterior inflammation. The greatest caution is necessary, however, in its use, because it must be remembered, when *inhaled*, this gas is poisonous.

This carbonic acid fountain, by being used the upper side down, when the gas alone without the liquid escapes, can be used wherever a moderate supply of some 30 or 40 gallons of the gas is required.

Others gases, as for instance, oxygen, chlorine, &c., might be preserved compressed in these fountains.

II. *On Solution of Iodine and Pyrophosphate of Iron.*

Mr. E. Fougera, Pharmaceutist of the Long Island College Hospital in New York, has forwarded to me some new preparations. At our last meeting I had not yet received the full details of these valuable preparations. They have since been given to me, and I beg to communicate them to the members of the Institute.

For his numerous experiments to dissolve iodine in syrup, he made the following observations:

1. The spontaneous decomposition of iodide of iron dissolved in syrup, is arrested at a certain point, and goes no further, even when exposed for months in a cellar, covered simply by a cap of paper.

2. This slightly decomposed syrup, or only colored with a small quantity of iodine, added on purpose, becomes perfectly white after a long exposure to the rays of the sun, or a moderate heat. But placed in the dark, its amber-color re-appears.

The first fact overthrows the existing theory of the decomposition of the syrup of iodide of iron, explained by the formation of a protoxide of iron and of hydroiodic acid, by means of the decomposition of water into its elements, and the subsequent transformation of the protoxide into sesquioxide of iron by the oxygen of the air. It is evident that, if the decomposition of the water and of the iodide of iron takes place in this way, it would certainly continue until all the iodide of iron is decomposed, a circumstance that does not take place.

To explain the second fact, I asked myself what became of the free iodine; evidently it could not combine with the iodide of iron; further we know that scarcely $\frac{7}{1000}$ of iodine will dissolve in water, to form, as some chemists maintain, iodic and hydroiodic acids. It remained only to ascertain what action free iodine has on sugar.

To solve this question, I made numerous experiments with iodine and syrup of sugar, and found immediately that under a slight and prolonged heat, the pulverized metalloid added to the syrup is therein dissolved in all proportions.

Up to 2 grammes of iodine added to 30 grammes of syrup, I obtained a colorless solution. The larger the proportion of the iodine is, the more care is necessary to take the syrup from the bath so soon as it is white. If further exposed to heat, the syrup becomes dark, the sugar being converted into caramel; this caramel in its place, becomes also decomposed under generation of carbonic acid, leaving a light black and spongy residuum, which is partly soluble in water and alcohol. Treated with hydrochloric acid, potassa, &c., this substance comports itself like ulmine and ulmic acid. To construct the operation to the entire decomposition of sugar, the necessary precautions have to be taken to evade the fracture of the glass by the expansion of the gas, which forms itself in large quantity, especially when the heat is somewhat elevated.

This iodated syrup has sometimes the odor of fruit; it is acid, unalterable in the air, decomposed at 100° Centigrade, and contains much glycose. Treated by re-agents it comports itself like iodides in general.

Here are the facts; it remains to give the theory. Does the iodine combine with the sugar, C_{12} H_{11} O_{11} F, or with the glycose, C_{12} H_{14} O_{14} J, as it does with starch, C_{12} H_{10} O_{10}, to form iodides? Or does the iodine in presence of sugar, which would act by catalysis, decompose the water and form iodic and hydroiodic acids? Which acids are formed, and are they formed at the expense of the water, or the sugar? Bromide acts in the same way, only more rapidly.

Chlorine acted on syrup still more rapidly than bromine. To water that had recently been saturated with chlorine under cold, sugar was added, and gently heated. In less than half an hour, the chlorine had disappeared and the liquid was slightly acid. It is probable that the chlorine was transformed into hydrochloric acid.

The iodated oil contains 8 grains of iodine, 1 grain of bromine, and 1 grain of phosphorus to the pint. It is prepared as follows: In 4 oz. of iodated syrup are dissolved (in the cold) in a mortar 8 grains of iodine; one pint of oil is added, and the whole well agitated. After the liquids have separated the syrup is decanted. One grain of bromine is dissolved in a little bromated syrup, and added to the above-mentioned pint of iodated syrup, mixed, and the syrup after standing decanted. As to the phosphorus, it is dissolved in a little oil at a gentle heat, and then mixed with the above-named preparation. The whole is finally filtered.

These oils have received the testimonials of the highest authorities, and Mr. Fougera deserves the thanks of the chemist as well as of us all, for his communications. This *Pyrophosphate of Iron*, ably elucidated by Dr. O. N. Chapman, of this city, as well as other preparations, deserve a wide-spread reputation, being prepared in the most careful and reliable manner.

Dr. J. A. Thompson, of Auburn, New York, presented his patent Photograph Cabinet, for the exhibit and preservation of Photographs and other Pictures. This cabinet is so arranged that the pictures are readily brought into view and exhibited beneath a plain transparent glass, producing the full softening effect of a frame. They are excluded from the injurious action of air, light, moisture, dust, and handling, which are so necessary in the preservation of these delicate pictures, that his cabinet cannot fail to take its place among the useful and ornamental inventions.

U. B. Vidal's improved Coal Oil Lamp was exhibited. The wick in this lamp is brought from the reservoir through a wick-tube of the ordinary width, but near the top is spread out to double that width, so as to give a flame of great size and brilliancy.

Mr. John May exhibited his improved Vertical Submerged Paddle Wheels for canal boats. The paddles are contained within a vertical

revolving drum, from which they can be projected so as to strike the water on any side of the drum desired.

Philip Griffith's Patented Grate Bars, were also exhibited. These bars have dove-tailed projections and recesses at the sides, so that while they can be secured firmly together, one or more can readily be removed by sliding the bar back so as to disengage its dove-tailed projections from the recesses in the bar next to it.

Mr. H. Howson exhibited the following articles:

Robert Ross' improved Oil Cup, which has a central reservoir, and hollow spindle surmounted by a cup, so arranged in respect to a valve at the lower part of the reservoir, that on turning the spindle in one direction the oil will flow from the cup into the reservoir, and on reversing the motion of the spindle, from the reservoir on to the part to be lubricated.

Shaw's Tobacco Pipe, with a reservoir beneath the bowl for the reception of moisture from the mouth.

S. Winner's Self-instructing Scale for Pianos. This consists of a number of blocks, so formed that they may be readily placed against the key-board of a piano; resting on the keys without interfering with the action of the latter. On the blocks are painted lines representing a musical staff, with notes, each of which represents the key directly beneath it, the letter or name of the note being painted directly below the latter, so that the scholar as he strikes a key, may see at once its name and the position on the staff of the note designating it.

W. Starkey's improved Lamp Chimney. The lower part of the chimney is of glass, which is surmounted by a metallic rim, to which is secured at two or three points, a cone-shaped funnel. The connexion between the latter and the rim is so slight, that the heat imparted to the funnel by the hot gases arising from the flame cannot be transmitted to the rim or the glass, which is consequently prevented from becoming suddenly or unequally heated.

Alden's "Chuck" for Lathes, from each of the "jaws" in which a pin projects into a curved radiatory groove in the face of a disk; the turning of the disk, in one direction or the other, opening or closing the jaws.

Specimens of Fire-Arms, manufactured by C. Sharps. Also, Sharp's Self-priming Pistol, manufactured by S. Butterfield.

C. Hutchinson's Tobacco Pipe, in which a moistened sponge is arranged between the bowl and the opening leading to the stem, to cool the smoke before passing to the mouth.

Specimens of Japanese Paper, which both in appearance and texture bears a strong resemblance to morocco.

Messrs. Altemus & Co.'s improved hinged-back Album, in which each leaf of the Album is secured by means of a leather hinge to the one next to it.